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THE NATIONAL INFORMATION INFRASTRUCTURE AND DUAL-USE TECHNOLOGY TRANSFER

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13. ABSTRACT *(Maximum 200 words)*

This report focuses on an efficient extension to traditional technology transfer practices using the World Wide Web's (WWW) interactive features to promote the transfer and commercialization of technology developed by Rome Laboratory (RL). Emphasis was on aligning the technology transfer portion of the RL Web site with the need of private sector technology transfer professionals and the business processes of the Technology Transfer Office (TTO) at Rome Laboratory. Concepts and principles guiding the organization, structure, and design of Web sites as a suitable medium for electronic technology transfer are from the literature on transaction costs, marketing, diffusion, information retrieval, and strategic networking.

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

FIGURES

TABLES

EXECUTIVE SUMMARY

This report focuses on an efficient extension to traditional technology transfer practices: using the World Wide Web's (WWW) interactive features to promote the transfer and commercialization of technology developed by Rome Laboratory (RL). Emphasis was on aligning the technology transfer portion of the RL Web site with the needs of private sector technology transfer professionals and the business processes of the Technology Transfer Office (TTO) at Rome Laboratory. Concepts and principles guiding the organization, structure, and design of Web sites as a suitable medium for electronic technology transfer are from the literature on transaction costs, marketing, diffusion, information retrieval, and strategic networking.

The authors adopted a customer- and user-orientation in organizing, structuring, designing, and implementing the Web site as opposed to the all too often encountered "hot" and "glitzy" features design methodology. Knowing what content is to be placed on the Web site is dependent on knowing what the purpose of the Web site is, who the intended and actual target audience is, and what the target audience expects from the Web site. A questionnaire was developed and distributed to private sector technology transfer professionals ascertaining how to best link RL with them via the WWW. Specifically, the questionnaire focused on what content ought to be provided by RL's TTO via the Web to facilitate technology transfer. Survey results confirmed that the customer- and user-orientation was the correct choice. Technology transfer professionals want a technology transfer Web site rich with content that provides them with the information they need to perform their job.

The research guided the reorganization of the technology transfer section of the RL Web site, thus bringing it in line with the needs of private sector technology transfer professionals. The changes link and integrate the RL TTO electronically via the WWW. A WWW home page was also developed focusing on a Rome Laboratory technology, the Phase-Only Filter (POF), to be transferred via the Internet.

A future vision of the Rome Laboratory Web site is offered. The Rome Laboratory Technology Transfer Web site can serve as an umbrella Web site covering the various Rome Laboratory Directorate Web sites. The content provided by the various directorates on their respective Web sites can serve as building blocks for the Technology Transfer Web site.

The TTO can draw on the contents of Directorate Web sites in building a Web site devoted to transferring Rome Laboratory technology. The TTO will provide the uniformity so desirable in presenting Rome Laboratory and its technologies as a unified unit as opposed to four separate directorates.

A next logical progression of the Rome Laboratory Web site is the development of a virtual marketplace for a technology area. A Virtual Technology Market (VTM) will bring together researchers, industry, government agencies, and users interested in the technology area. VTM will facilitate communication and technology transfer between research providers, research users, and industry by bringing together all the stakeholders.

If only one major recommendation had to be made, minimally for the Web site to be useful in promoting technology transfer it must be kept up-to-date with the appropriate information sought by the private sector.

The National Information Infrastructure and

Dual-Use Technology Transfer

I. INTRODUCTION

This report focuses on an efficient extension to traditional technology transfer practices: using the World Wide Web's (WWW) interactive features to promote the transfer and commercialization of technology developed by Rome Laboratory (RL). The task involved overhauling the Technology Transfer Office's (TTO) home page on the Rome Laboratory Web site. The focus was on reorganizing and developing content in a way that will be more meaningful to private sector technology transfer professionals. The RL Web site, as have other Web sites, has undergone change over the last two years as Web site developers and users gained a better understanding of this technology and the opportunities offered by it. There has been the realization that having a home page on the WWW and providing information on the laboratory is not sufficient; the information content must reflect the potential user's information needs. Knowing what content is to be placed on the Web site is dependent on knowing what the purpose of the Web site is, who the intended and actual target audience is, and what the target audience expects from the Web site.

The authors in this report present the various tasks that were carried out in aligning the technology transfer portion of the RL Web site with the needs of private sector technology transfer professionals and the business processes of the Technology Transfer Office at Rome Laboratory. The authors begin by tracing in section II the historical

development of Web sites within organizations and apply it to the case of Rome Laboratory. They then present in section III the literature guiding the organization, structure, design, and depiction of WWW sites as a suitable medium for electronic technology transfer. Our orientation takes into account important concepts and principles such as cost, marketing, diffusion, information retrieval, and strategic networking.

In section IV the authors present the work carried out in addressing the following tasks:

- Using the Internet and the WWW to link RL electronically over the information superhighway with private sector firms.
- Identifying potential external users, companies interested in RL technology.
- Linking interested parties with RL through various electronic means.
- Evaluating the overall usage of various electronically available resources and systems as they pertain to technology transfer at RL.

The above tasks were accomplished by identifying and surveying private sector parties interested in RL technology. A questionnaire was developed and distributed to private sector technology transfer professionals as to how best link them with RL via the WWW. Specifically, what content ought to be provided by the RL's TTO via the Web to facilitate technology transfer. The authors made every effort in adopting a customer- and user-orientation in organizing, structuring, designing, and implementing the Web site as opposed to the all too often encountered "hot" and "glitzy" features design methodology. As the survey results show, we were correct in adopting this orientation. Technology transfer

professionals want a technology transfer Web site rich with content that provides them with the up-to-date information they need to perform their job (Wigand, Marcinkowski, Martens, and Plonisch, 1996).

Based upon the user's perspective, the authors in section V describe how the technology transfer portion of the RL Web site was reorganized, thus bringing it in line with the needs of private sector technology transfer professionals. The changes link and integrate the RL TTO electronically through the site to the private sector. This electronic linkage will facilitate communication between the RL TTO and the private sector. The TTO can provide timely and useful information via the WWW, and the private sector can review this information and submit requests in electronic form for further information or can use the information found at the Web site to contact the TTO through more conventional means such as the telephone.

In section VI the authors present the work performed in designing and implementing a WWW home page devoted specifically to a particular Rome Laboratory technology, the Phase-Only Filter (POF), for transfer via the Internet.

In section VII the authors go on to discuss how various search engines work and give recommendations on the design elements to be included so that major RL home pages are properly indexed by various search engines.

In section VIII usage statistics of the Rome Laboratory Web site by RL and RL external users are presented. Detailed statistics on who accesses what are presented for an average week.

Section IX contains information on where on the WWW information is available to guide TTO clerical staff in updating already existing Web pages. This information on basic HTML language coding will enable the TTO staff to edit, update, and create Web pages. An explanation is provided on how any word processor can be used to edit a home page.

Finally, in section X the authors summarize their recommendations and lessons learned. Moreover, they provide an overall future vision of the TTO section of the Rome Laboratory Web site and how it relates to the general Web effort at the Laboratory.

II. A HISTORICAL PERSPECTIVE OF WEB SITE DEVELOPMENT

The notion of what constitutes a "good" Web site has changed over the last two to three years. As Web site users and developers gain a better understanding of this technology and the opportunities offered, their standards rise. Over time, Web sites placed on-line have undergone a shift from static to interactive sites. Peter Adams, creative director for on-line services for New York-based Poppe Tyson Advertising, has classified the evolution of Web sites into four epochs: Genesis, Renaissance Age, Age of Enlightenment, and Nirvana (deJong, 1996).

Genesis describes the initial state of Web sites with the advent of Mosaic, a WWW browser. This era was characterized by the early discoveries of how to develop and use the Web by both Web site developers and users. Development of an organization's Web site was usually in the hands of technically oriented people. Little consideration was given to the content placed on-line. Content development primarily consisted of the scanning in of easily available printed material. Hyperlinks were added to link various material and navigational buttons were added to facilitate the linkage to material on this site or to other sites.

Most, if not all, Web sites in the *Genesis* stage experienced what can best be described as the scanning stage. Rome Laboratory was not immune to this syndrome. No new content specifically designed for this new medium was developed. Brochures, manuals, organization charts, technology descriptions, etc. were all scanned in and placed on the Web. Furthermore, all sites in this stage experienced peaks and valleys in the number of visitors browsing their site. Initially whenever a site was announced, there would be a flurry of visits by other Web surfers to see what someone else had done and to learn from it. As new sites were announced, the

number of visits would trail off to a steady state. Web site developers would push the edge of technology so as to again attract everyone back to their site. The Web site's content was not the drawing feature, after all, this was the age of discovery. The focus was on harnessing and learning the technology. In testing the limits and the technology's possibilities Rome Laboratory developed the Snowball Cam. The Snowball Cam allowed a Web surfer to throw a virtual snowball at a picture taken in real time of people at the laboratory. Even though the Snowball Cam added very little value in terms of content to the Web site, it was however, very successful in promoting the presence of the Rome Laboratory Web site.

In the *Renaissance* stage, control of site development began to shift from technical to marketing people. This was the age when having one's site declared the *cool* site of the day or week was the epitome of success. The sites became more sophisticated and more appealing to the eye. However, the focus on content was still lacking. There really was not much content behind the glitzy graphics to make a visitor want to revisit the site on a regular basis. Web sites were merely an extension of an organization's communications department. Once company brochures and related material were read, there was no compelling reason to return to the site. Graphics along with contests with prizes were all attempts to entice visits to a site.

The Rome Laboratory Web site in this stage also began to look more professional with better designed graphics and layouts. New content was being developed especially for the site. However, the content and organization still reflected what the laboratory wanted to project to the outside world and what it felt potential visitors to the Web site wanted to see. Users were left out of the design loop.

In the third stage, the *Age of Enlightenment*, organizations became aware of the Web's possibilities for changing the way they conduct business. Web sites representing the third stage are just beginning to appear. For Rome Laboratory this meant that the TTO could use the WWW as a means to electronically link current existing business relationships with the private sector (Wigand, Marcinkowski, and Plonisch, 1995a, 1995b). In addition an effective technology transfer Web site will allow Rome Laboratory to forge new business relationships with the private sector via electronic means. However, to design and build a Web site that meets the needs and provides solutions to the targeted customer demands an understanding of the user community. The Gartner Group reported that 90% of the surveyed companies built their Web sites without ever consulting the end users of their sites (Kline, 1996).

In the fourth stage, *Nirvana*, the Web becomes another extension in how business is conducted. The fourth stage is yet to be reached by any Web site. The reorganization of the technology transfer part of the RL Web site will bring the laboratory a step closer to Nirvana. As technology changes and Web sites are changed to reflect this, the Web will become an indispensable venue by which to conduct technology transfer, just as the telephone and other means used today.

III. CONCEPTUAL APPROACHES

Five different approaches to a reconceptualization of the technology transfer process, especially when this process occurs electronically, are advanced below. The authors then present the literature guiding the organization, structure, design, and depiction of WWW sites as a suitable medium for electronic technology transfer. Our orientation takes into account important concepts and principles such as cost, marketing, diffusion, information retrieval and strategic networking.

III.A. Transaction Costs Theory

Economists have categorized transactions among organizations as those that support coordination between buyers and sellers, i.e., market transactions, and those supporting coordination within the firm. Williamson (1981) points out that the choice of transaction depends on a number of factors, including asset specificity, the parties' interests in the transaction, as well as ambiguity and uncertainty in precisely describing the transaction. Transaction costs may then be broken down into production and coordination costs (Benjamin and Wigand, 1995; Malone, Yates, and Benjamin, 1987). In this context, coordination costs include the transaction (governance) costs of the information processing necessary to coordinate the work of people and machines performing primary processes.

Firms will choose transactions that economize on coordination costs. As information technology continues its rapid cost performance improvement, the unit cost of coordination transactions will approach zero, thus enabling the design of innovative coordination

transactions to fit new business needs (Benjamin and Wigand, 1995). The ever-increasing and innovative use of the WWW to conduct business and WWW-related forms of electronic commerce are clear examples of organizations' desire to economize on transaction costs. One may argue that with cheap coordinative transactions, interconnected networks and their strategic deployment, and easily accessible databases, a proportional shift of economic activity to cheaper electronic communication channels to conduct the organization's business can be expected.

III.B. Marketing

All marketing efforts are based on the basic premise that there is a specific consumer audience. Consumers, in the present context, are a set of specific firms within an industry or the private sector at large, which have needs that can be filled by other firms operating within a specific market. In this case, a federal laboratory constitutes a firm filling the demand for specific technologies that can be marketed and commercialized by private sector firms.

Three main policies of orientation within the marketing effort may be identified: customer orientation, product orientation and profit orientation. The latter orientation is not an appropriate orientation for a federal laboratory. A product orientation is predicated on the view that consumers will recognize and appreciate products for superior merit and bestow their patronage on firms--in this case the product is research and development. However, most federal laboratories have customers inside the federal government. A customer orientation denotes (a) an attitude and a pattern of conduct, as well as (b) the extent to which a federal

laboratory tries to determine what its federal customers want and then gives them what they want.

The basic challenge faced by a federal laboratory, then, is to identify needs and provide a linkage between them and the customer outside the federal government, i.e., a firm interested in a specific federal laboratory technology. To maximize this linkage and relationship to such customers, a federal laboratory needs to form hypotheses and understanding about present and potential customers. Included should be questions such as:

- What affects customer behavior?
- Which channels (advertising, face-to-face contacts, publications, etc.) reach customers?
- What is the degree or strength of need or desire for the product?
- What are the appropriate appeals (or arguments) to which customers are most responsive?
- What is the customer's responsiveness to different types of sales devices, i.e., their ability to be influenced by technology transfer discussions by the technology transfer staff, engineers and scientists?

After these questions have been answered, the marketing dimension entails five general activities:

1. Identifying and selecting the type of customer that the federal laboratory chooses to cultivate and learning the firms' requirements.
2. Designing products, know-how and services, including facilities, that the federal laboratory can transfer in conformity with customer desires.

3. Persuading customers to acquire and adopt products, know-how and services.
4. Displaying, moving, and to some extent storing products, know-how and services after they have been developed at the laboratory.
5. Identifying dual-use technologies and applications.

In designing its products, acquiring and developing know-how, and deciding how much and what specific services to offer, federal laboratories will unquestionably benefit from having a clear picture of their *target customer*. The research reported here attempts to provide a linkage, an *electronic marketing and information channel*, between these target customers and the federal laboratory.

III.C. Diffusion

Diffusion is the social process by which an innovation is communicated through certain channels over time among members of a social system (Rogers, 1995). This process clearly resembles the task at hand for federal laboratories in the technology transfer process: i.e., a technology or an innovation needs to be communicated to a set of firms (members of a social system) within a particular industry. The communication channel chosen for the present study is that of electronic transactions through the use of the Internet and WWW. The authors view such electronic diffusion means as timely, cost-effective, and focused methods of reaching the target customer described above.

The rate of diffusion or adoption of that technology is determined by the characteristics of the innovation (e.g., the relative advantage, compatibility, complexity, trialability and observability).

The communication channel chosen determines, in part, the likelihood of making a successful linkage with the target customer. General diffusion principles posit that, ideally, successful communication occurs in a face-to-face setting with the target audience or customer. This, however, is often impracticable or too expensive. Substitutes for face-to-face settings are chosen and the mass media come into play. The use of mass media for advertising is often a vague undertaking, since one cannot be sure that one's message truly reaches the intended target. Mass media follow a passive one-to-many communication model whereby a firm reaches many current and potential customers through efforts that allow the customer limited forms of feedback. Often a compromise between the two extremes is desirable, e.g., the use of mass media, followed up by face-to-face meetings with smaller groups, etc. The Internet and the WWW facilitate an interactive multimedia one-to-many communication model, where feedback from the customer plays an important role.

Electronic messaging via the Internet comes close to this ideal, i.e., using a cost-effective one-to-many medium while still reaching specific individuals. Moreover, the Internet's use makes it possible to be interactive with specific individuals within the target group and thus allows customized, *almost* face-to-face-like interaction, if one uses the interactive multimedia and feedback capabilities of the WWW. This potential for interactivity certainly makes the medium highly attractive as requests, requirements, etc. certainly can be customized. Moreover,

such interactivity, sometimes called *interactability,* makes possible the often missing *feedback* in the technology transfer process. Such feedback allows one to shape and additionally customize the very next step in the diffusion and communication process reflecting the target customer's needs. Such customization is almost impossible when viewing the diffusion process via traditional advertising as a communication channel. Internet and WWW capabilities require the development and application of new concepts and models for marketing technology. The Internet and WWW will have a profound effect on how technology transfer is done.

III.D. Information Retrieval

In electronic dissemination, it is obvious that the users can readily retrieve information once the information is stored on the system. There are many data bases available at federal laboratories that could be accessed through the Internet, and many of those pertain to technology transfer and related issues. The authors made every effort to identify such data bases and especially data bases that are accessed by the Technology Transfer Office, in order to answer technology transfer inquiries. Such data bases need to be made available in a format conducive for use by outside users, hopefully firms that might acquire a particular product, know-how or service. The design of such information, data bases, etc. often determines their successful use. In this sense, a customer or *end-user* orientation must be employed in the design of the system. Unless such design is inviting, encouraging, timely, informative, and user-friendly, the success of the system is highly questionable (Taylor, 1986).

III.E. Strategic Networking

Networking as a conceptualization includes all four of the above topics, without which networking could not take place. Networking in this sense goes beyond the traditional means of reaching a target customer. George Kozmetsky, director of the IC2 Institute, Austin, Texas, stated at a conference on commercialization of technology from federal laboratories that, "The secret to successful commercialization of technology developed in federal labs is networking, networking, networking." (Kozmetsky, 1993). This importance was already demonstrated in an empirical NSF-funded study by Wigand focusing on technology transfer issues within the microelectronic industry and the role of industry, government, and universities (Wigand and Frankwick, 1989). Other authors, including Ciborra (1993), Jarillo (1993), and Wigand et al. (1996) have stressed the importance of strategic networking and collaboration. This approach enables technology transfer that is simultaneous, efficient, flexible, conducive to innovation, and adds value to processes and the organization.

Networking denotes interaction, feedback, collaboration, customizing and creating a dialogue to a degree that otherwise would not exist. Electronic networking suggests the creation of Listservs, electronic bulletin boards (discussion groups), direct electronic inquiries that might be shared with the rest of likewise interested individuals/firms around a particular product, know-how or technology. Such individuals (within different firms) appear to be quite interested in such dialogue as a technology emerges, although it is understandable that such dialogue would be reduced or cease entirely once the technology becomes highly marketable or commercializable due to competitive reasons. But, even if an organization such as a federal

laboratory could speed up the development and diffusion of a technology to such a point and if interaction would then discontinue, the laboratory still would have provided a most valuable service to the development of that technology and industry.

In the next section, the authors begin to present the actual work carried out in electronically linking via the WWW the business processes of private sector technology transfer professionals with those of the TTO at Rome Laboratory. The work performed took into account important concepts and principles such as cost, marketing, diffusion, information retrieval and strategic networking. The authors made every effort in adopting a customer- and user-orientation in organizing, structuring, designing, and implementing the Web site.

IV. DESIGNING THE ROME LABORATORY TECHNOLOGY TRANSFER WEB SITE

In this section the authors present the actual work carried out in addressing the following tasks:

- Using the Internet and the WWW to link RL electronically over the information superhighway with private sector firms.
- Identifying potential external users, companies interested in RL technology.
- Linking interested parties with RL through various electronic means.
- Evaluating the overall usage of various electronically available resources and systems as they pertain to technology transfer at RL.

In addressing these tasks a questionnaire was developed and distributed to private sector technology transfer professionals ascertaining how to link RL best with them via the WWW. Specifically, we inquired what content ought to be provided by the RL's TTO via the Web to facilitate technology transfer. The authors were concerned in adopting a customer- and user-orientation in organizing, structuring, designing, and implementing the Web site as opposed to the all too often encountered "hot" and "glitzy" features design methodology. As the survey results show, we were correct in adopting this orientation. Technology transfer professionals want a technology transfer Web site rich with content that provides them with the information they need to perform their job.

Content and interactivity are most important for RL to consider when using the WWW as a means of extending how to conduct business and serve customers' needs. Visitors'

expectations of what a Web site can do for them today are heightened. A typical user of the Web today views the Web as a resource that can provide useful information, deploying search engines such as Alta-Vista, Lycos, Yahoo, etc. to locate sites containing desired information. The decision to visit and to continue visiting a particular Web site is based on the user's belief that the site contains relevant information that can be used to solve a problem or overcome an information gap. Glitzy and nifty graphics while enticing to the eye and quite effective in catching the user's attention are, however, not enough to keep the user coming back time after time in the long run.

The authors' Web site design philosophy is based on the following three questions, all user-oriented:

1. What is the Web site's purpose?
2. Who is the target audience?
3. What information does the target audience want to see?

The design of a successful Web site rests on the answers to these three fundamental questions. Success is judged by whether members of the target audience visit the Web site at regular intervals, knowing that the site's content is likely to meet their information needs, and provide answers to their questions.

IV.A. Methodology

Two distinct methodological approaches were used to answer the three questions above. The first question, "What is the Web site's purpose?", applies to the organization wanting to build the Web site. A set of interviews with members of the Technology Transfer Office (TTO) were scheduled to reflect and, subsequently, understand their vision of what they wanted to accomplish by revamping the current site. These discussions also focused on the second question, "Who is the target audience?"

A survey approach was used to fully answer questions two and three. The purpose of question three, "What information does the target audience want to see?", was to find out whether the target audience was familiar with and already using the Internet and the WWW, and for what purposes. The aim was to see how receptive the target audience would be to conducting technology transfer via the Web. The basic premise of our research was that they would be open to the idea only if the content provided by the Web site met their information needs as private sector technology transfer professionals.

IV.B. Survey Administration

A questionnaire (**Appendix A: Survey-Questionnaire**) consisting of 65 questions was developed to answer the broad questions two and three. It was mailed in the winter of 1995-1996 to 260 attendees of a recent national technology transfer-related conference hosted by Rome Laboratory. Non-respondents received a reminder and another copy of the

questionnaire six weeks later. The survey was designed to reflect the interaction of private sector firms in regard to technology transfer activities with federal laboratories at large.

The survey sample represented a cross section of people and organizations interested in federal laboratory technology: all potential users of a Web site built for technology transfer. The organizations for which respondents worked ranged from very small consulting firms, entrepreneurial firms, medium sized firms, to very large defense-related firms. Attendees at this conference represented organizations from across the United States.

The questions posed consisted mostly of open-ended questions. The intention was to elicit as much information from the respondents on their information-seeking behaviors and WWW familiarity and usage, without imposing a preconceived notion on how they might answer by offering multiple choice questions. The questionnaire was designed to take 20 minutes to complete. The answers to the open-ended questions were then content-analyzed. The survey data were entered into the SPSS software package for detailed analysis.

Of the 260 attendees surveyed, 84 completed questionnaires were returned, thus giving a response rate of 32%. Analysis of the demographic information and identifying information given by those who chose to forego anonymity revealed that the respondents were a good representation of the type of firms to be served by the technology transfer Web site.

IV.C. Survey Results

A Web site, to be useful for electronic commerce, must reflect the information needs of the target audience it is to serve. In the present case, the target audience are those private sector individuals interested in Rome Laboratory technology for the purpose of commercializing it. In broadest terms, these individuals are interested in learning what is happening in the laboratory so that their organizations can make use of developed technology. Furthermore, it is important to ascertain whether the intended target audience has knowledge of, and is using, the WWW. Also, it is important to know whether they are open to the idea of electronically interacting with TTO offices.

What follows is an executive summary of the survey results. More detailed graphs are located in **Appendix B: Survey-Results**.

IV.C.1. Profile of the Respondents

The prototypical respondent was a male senior-level program manager in his fifties, who has held his current position for approximately five years and is involved in technology transfer activities at a large defense-related civilian contractor firm. 93% of the respondents worked at for-profit firms, with 52% employed at firms with 500 or fewer employees, and 48% employed at firms of more than 500 employees.

IV.C.2. Information-Seeking Behavior of the Respondents

In response to the question of how they rated the importance of methods employed while seeking technology transfer information, 54% of the respondents answering this question preferred personal contact methods (including personal meetings, conference attendance, and phone conversations), 29% preferred written contact methods (including the reading of lab publications), and 17% preferred electronic contact methods (e-mail, etc., World Wide Web browsing , etc.). The most widely-read publication by respondents was *Commerce Business Daily.*

IV.C.3. Respondents' Contact With Federal Lab Technology Transfer Offices

Approximately 90% of the survey respondents estimated the current frequency of their contact with Federal laboratory technology transfer offices. 43% made contact between one and four times a year, 21% made contact more frequently than four times a year, and 36% made contact less than once a year. When respondents do contact technology transfer offices, 44% of the time the request is general in nature; 42% of the time the request is specific is nature. The methods employed in contacting the technology transfer office were: face-to-face meetings (37%), phone contact (23%), electronic contact (14%). and requests for written material (15%).

In response to the question as to whether they believed that there was any need for improvement in the process of technology-transfer-related information exchange with Federal laboratories, 75% of the respondents agreed that there was a need, 21% were neutral, and 4%

disagreed. Most of the suggestions for possible improvements (32%) centered around providing electronic access to Federal laboratory technology transfer information. Other suggestions were to accelerate the release of current information (20%), to provide more methods of interaction with the commercial sector (16%), to improve the technology transfer office's visibility (15%), to improve procedures perceived as bureaucratic (7%), and to adopt a more market-driven orientation (7%).

Lending some support to the concept that electronic means of communication are perceived as a way of improving technology transfer information exchange processes, 79% of the respondents gave an affirmative reply to the question as to whether they would be willing to fill out an electronic inquiry form supplied by a Federal laboratory technology transfer office.

IV.C.4. Respondents' Utilization of the Internet

When asked whether they utilized the Internet, 86% of the respondents indicated that they and their organizations currently had access to the Internet, and 80% of those respondents identified themselves as regular users, spending between one and 20 hours per week performing Internet-related activities. The mean time per week spent on Internet-related activities by these regular users was three hours and 48 minutes. Approximately 31% of these regular users have had access to the Internet for less than a year, 29% had had access for less than two years, 28% had had access for less than five years, and 12% had been accessing the Internet for five years or more. Asked to specify how they utilized the Internet,

32% of the regular users indicated using it for e-mail, 24% for searching for specific information, 21% for downloading information, 18% for performing non-specific searches, and 5% for accessing general information. Asked to rate the importance of various features of the Internet, 25% selected e-mail as important, 25% selected the World Wide Web, 21% selected FTP, 12% selected USENET, 10% selected Gopher, and 7% selected Listservs.

This may indicate a shift in the perceived importance of various Internet functionalities to the technology transfer community, as none of the respondents chose to identify any particular Listserv or USENET group as particularly significant to the dissemination of technology transfer information. Utilization of the Internet itself is already relatively high in the technology transfer community.

IV.C.5. Respondents' Utilization Of The World Wide Web

83% of the respondents indicated that they and their organizations currently had access to the World Wide Web, and 75% of those respondents said that their organizations had their own home page. 90% of the respondents with access to the Web claimed to be regular users, spending between one and 15 hours on Web-related activities. These hours are in addition to the Internet-use hours mentioned above. The mean time per week spent on WWW-related activities, in addition to the Internet usage identified above, was three hours and 35 minutes. For these self-identified regular users of the WWW, therefore, the equivalent

of almost one full day (seven hours and 24 minutes) in a standard 40-hour workweek is already being spent in the electronic communication environment.

IV.C.6. Respondents' Computing Platform Configurations

The most common computing platform configuration was an IBM personal computer or compatible, used either alone (45%) or in conjunction with either a Macintosh or Sun computer (17%). Macintosh-only platforms accounted for 30% of the remainder, with Sun-only users accounting for 3%, and a Macintosh-Sun combination accounting for another 3%.

The most frequently used browser was Netscape (84%).

IV.C.7. Respondents' Use of the WWW to Facilitate Technology Transfer

67% of the respondents with World Wide Web access indicated that they regularly used the Web to peruse Federal laboratory home pages. Their discovery of these home pages was through browsing (36%), through previous knowledge gained by regular business activities (33%), through word-of-mouth (22%), through advertisements (5%), through conferences (2%), and through targeted searches (2%). The criteria for choosing particular Federal laboratory home pages to scan were: potential for contractual opportunities (59%), congruence of laboratory mission with firm's area of expertise or interest (35%), geographic proximity (4%), and ease of access to the home page itself (2%). For those who perused Federal laboratory home pages, 43% indicated that their perusal of the page resulted in additional (non-Web) contact with the specific Federal lab. Methods of contact included

telephone (40%); e-mail (30%); written correspondence (11%); electronic form on the home page itself (9%); fax (6%); and in-person visits (4%). The particular entity contacted at the Federal laboratory was generally not the technology transfer itself, as only 31% of the contacts reported were directed to the technology transfer office. The other entities contacted at the Federal laboratory as a result of these home page-driven inquiries were: a listed point of contact (40%); a technical contact (40%); a particular contracting office (10%); a small business contact (5%); and a legal affairs contact (5%).

Of those respondents who regularly connected to the Federal laboratory home pages, 62% of them indicated that they preferred particular laboratory home pages which they visited on a regular basis. That basis ranged from weekly for 49% of these regular visitors, to monthly for 43%, to daily for 3%, with the remainder indicating that their perusal of these favored home pages were on an "as needed" basis.

IV.C.8. Respondents' Information Needs From the Technology Transfer Office

Figures 1 and 2 illustrate the responses given to questions referring to the type of information the target audience felt that was important to have from the Technology Transfer Office. Results indicate that the target audience is very interested in seeing descriptions on-line of work currently being done at a laboratory and what future work will be done. Along with this information, respondents are keenly interested in having the points of contact (POC) provided for a particular technology listed, and how to contact them. There is also interest on general technology transfer information probably stemming from companies that are unfamiliar

FIG 1 MOST IMPORTANT INFO PROVIDED BY TTO

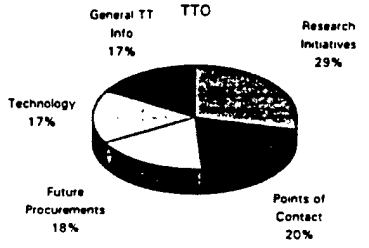


FIG. 2 ADDITIONAL INFO TTO SHOULD PROVIDE

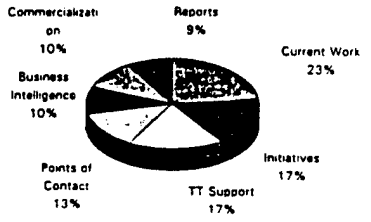


FIG. 3 WEB SITE SECTIONS OF INTEREST

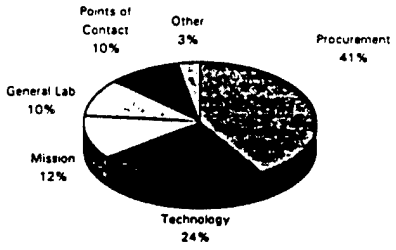


FIG. 4 REASONS FOR RETURNING TO WEB SITE

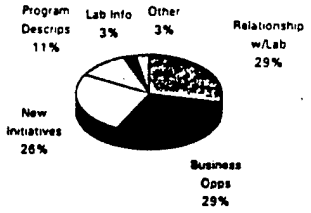
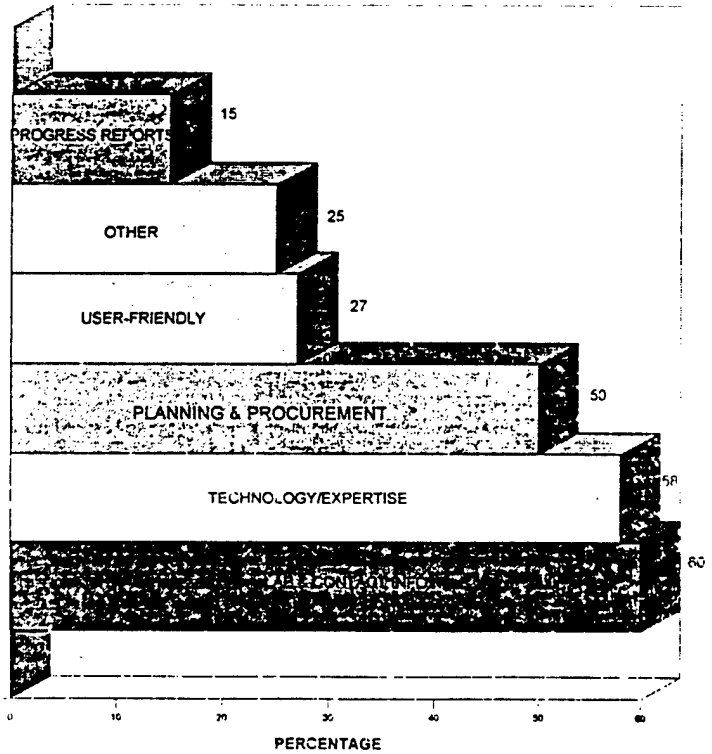


FIG.5 INDISPENSABLE CONTENT FOR WEB SITE [N = 60]



with laboratory TTO offices and what they offer. In addition, there is interest in the TTO providing ideas on how a particular technology can be commercialized.

IV.C.9. Current Technology Transfer Web Site Sections of Interest to Respondents

Figure 3 reflects what sections of current federal laboratory Web sites are of interest to the target audience. The section most often given as a response was procurement activities, followed closely by information on technology at the laboratory. Surprisingly, the choice of the point of contact section was infrequently mentioned. However, one must remember that the question addresses what is currently available, and the low showing of POC indicates that current sites are not doing a good job in providing information on who to contact about a particular opportunity. This is consistent with other questions in the survey; revealing that, for the most part, respondents indicated they wanted to know whom to contact relative to a particular opportunity or to information presented on the Web site.

IV.C.10. Reasons Why a Particular Technology Transfer Web Site Is Revisited

Figure 4 provides insight on what makes someone revisit a particular Web site. A major factor in revisiting a Web site is whether the organization already has an established working relationship with the laboratory. This is also an artifact of the study in that the sample consisted of those who already maintain a relationship with a federal laboratory. The Web site is used by these respondents to determine what new business opportunities there are, and what new initiatives the laboratory is planning to pursue. Another surprising low scorer is program

descriptions. One explanation is that laboratories currently are not adequately describing their various technologies on line. This explanation is supported by responses to other questions where respondents indicated that not enough descriptive information on current technological opportunities within the laboratory, or the technological expertise available, is reflected on the Web site.

IV.C.11. What Respondents Want to See on the Technology Transfer Web Site

Figure 5 illustrates what private sector technology transfer professionals (N=60) would include on a Web site if they were to design it. Of these respondents, 60% wanted information related to the laboratory and whom to contact. Of those responding, 58% wanted information on the type of technology and expertise currently available at the laboratory. Almost every respondent desiring technology and expertise information also wanted POC information. These two areas are not static: the laboratory must have an on-going effort to keep this information current. One of the major issues brought up by the respondents is that information provided must be up-to-date and accurate if it is to be of any use.

Another high scoring category was planning and procurement information (50%). Respondents wanted to know what types of opportunities are available to them. If such information is updated when it is available, then users will visit the site on a regular basis just as they probably first turn to other information sources important to them, such as reading *Commerce Business Daily* every day. For the Web site to be successful, members of the target

audience must begin to view the Web site as an important source of information about the laboratory.

Progress reports (15%) refer to updates on current work being done at the lab. Surprisingly, making the Web site user-friendly, such as providing a search engine for the site, was mentioned by only 27% of the respondents.

V. ELECTRONICALLY INTEGRATING THE RL TTO WITH THE PRIVATE SECTOR

As the survey results indicate Web site content is critical in the eyes of private sector technology transfer professionals. Also heavily stressed by the respondents was the importance of keeping the content up-to-date. The RL Web site already contained much of the content desired by the target audience. However, the content deemed important by the target audience was not easily and readily accessible to them. A visitor to the RL Web site needed familiarity with the Laboratory's organization to locate pertinent information.

The initial home page seen by a visitor ought to provide links to the information most pertinent to the audience. The visitor to the Web site should not have to trudge through page after page or have a complete understanding of the organization's units in order to locate the desired information. If the content most desired is neither easily locatable nor current, then the WWW site will serve no useful purpose in promoting and enhancing interaction between the laboratory and the private sector.

Based on respondents' comments, links to the following topics were included on the main technology transfer home page (http://www.rl.af.mil:8001/Technology/rl-techno-main.html) :

- General information on the laboratory
- Technology news focusing on current laboratory technology making the news
- Technology data base with point of contact

- Expertise data base with point of contact
- Partnering mechanisms such as CRDAs, Educational Partnerships
- Information related to small business programs
- Business opportunity announcements
- Contacting the Technology Transfer Office

A general introduction to the TTO office was included (http://www.rl.af.mil:8001/Technology/TTO-intro.html) describing the office, its specific technology transfer activities (http://www.rl.af.mil:8001/Technology/partnering_mech.html), and past accomplishments (http://www.rl.af.mil:8001/Technology/ Accomplish/accomp-main.html).

A brief introduction offering an overview of the major technology and program areas. and special facilities of the four directorates were included. These links serve the purpose of familiarizing a user with the four directorates at RL. A link to a directorate's Web site was provided for further detailed information. At the top of the page is a short description specifically written for correct abstracting of this page by various search engines. Also, meta-tags were included in the HTML code to facilitate proper abstracting of the page by the Alta-Vista search engine. An example of a directorate description is included in **Appendix C: Directorate Description**. It is important to note that this information was already on the RL Web site, but was buried in the Public Affairs (PA) section of the Web site. In addition, the information was out of date and not formatted to reflect the capabilities of the Web. Automated conversion from a word processing document to HTML code is a time saver. However,

someone needs to look at the document to see if the result is aesthetically pleasing, such as making sure that the document is single spaced throughout as opposed to some parts being single-spaced and other parts being double spaced due to the conversion. Also, the document needs to be enhanced with links for further information.

The user is able to search the various technology data bases available at RL (http://www.rl.af.mil:8001/Technology/tech_databases.html). For each of the data bases there are two choices: a full text search, and a listing of all material in the database organized appropriately. The listing associated with Rome Laboratory Success Stories (previously known as Technology Payoffs) is organized by technology area, and by category (technology transition, technology transfer, technical achievement). The technology data sheets are organized by directorate and by technology area. For each of these data bases the user is given multiple means by which to contact the TTO. One is by submitting electronically a technology inquiry form (**Appendix D: Electronic Inquiry Form**). Or, the user can contact the TTO through more traditional means such as by phone, given the proper information (**Appendix E: TTO Contact Information**).

The user is able to review the various RL technology transfer activities, such as technical assistance, Cooperative Research and Development Agreements (CRDAs), and Educational Partnerships, and facilities use (http://www.rl.af.mil:8001/Technology/partnering_mech.html). For each of these technology transfer activities the user is given multiple means by which to contact the TTO as described previously.

For technical assistance an alphabetical list organized by technology of technical expertise is provided. For those interested in establishing a CRDA with RL the following information is provided: information on the CRDA preparation process; information required for completing the legal portion; a model CRDA; and RL guidelines for preparing the work plan. In addition, information available only internal to RL personnel is provided: Air Force guidelines in using the model CRDA; CRDA administration; and RL technology transfer representatives.

For those interested in establishing an Educational Partnership with RL a template is provided. A description of the EP procedure available only to internal RL personnel is also provided. For those interested in using the facilities available at Rome Laboratory a listing and description of the various facilities available is provided. The listing is broken down by where the facilities are located: Griffiss Business and Technology Park (formerly Griffiss Air Force Base), Hanscom Air Force Base in Massachusetts, and other sites located in upstate New York and in Massachusetts.

Next, information on breaking news coming out of the laboratory is presented (http://www.rl.af.mil:8001/Technology/tech_in_news.html). This category is divided into two parts: press releases or announcements of Rome Laboratory technology, and the promotion of RL technology through advertisements appearing in various magazines and journals.

The category referring to press releases or announcements is partly based upon the information produced by the Public Affairs office. It is very important that this page be updated as press releases relevant to technology transfer are produced by the Public Affairs Office. This

involves only adding an appropriate hyperlink to the page referencing the document. This puts all the press releases or announcements related to technology transfer on one page, and also eliminates other non-relevant press releases or announcements that would just clutter-up the page. The other part is composed of articles written by scientists for various technology transfer publications.

TTO technology promotions appearing in various publications are presented. The user is offered a picture of the technology as well as a description. The picture is intentionally kept small to save on bandwidth. A larger version of the picture can be accessed by clicking on the smaller picture. In addition, hyperlinks to other pages at the RL Web site referring to the technology are provided for more detailed information (see **Appendix F: Technology Promotions**).

The hyperlink *Technology Links* is a listing of the various projects carried out in the directorates. In the future this will be superseded by actual directorate Web pages highlighting their respective technology.

In conjunction with the work of electronically integrating the TTO office, work was also performed on the Technology Diffusion Division's (XPD) home page (http://www.rl.af.mil:8001/Lab/XP/XPD/xpd-main.html). XPD controls the technology diffusion activities for Rome Laboratory such as technology transfer and small business programs like small innovation business research (SBIR), small business technology transfer (STTR) (http://www.rl.af.mil:8001/Lab/XP/SBIR/sbir-main.html). The RL SBIR announcements for 1997 were placed on the Web in this location.

A link to business opportunities such as Broad Agency Announcements (BAA), Program Research and Development Announcements (PRDA) administered by the contracting division (PK) were included on the same page in order to keep information related to business opportunities in one area. This allows the user to find all information regarding opportunities for business on one page.

VI. TRANSFERRING A TECHNOLOGY VIA THE WWW

VI.A. The Phase Only Filter (POF)

One of the tasks of this project was the development of a WWW home page focusing on a Rome Laboratory technology to be transferred via the Internet. Due to intellectual property considerations, only one technology, the Binary Phase Filter (BPOF), was identified by the Rome Laboratory Technology Transfer Office as a candidate technology for transfer via the Internet.

The first course of action was to develop an understanding of what the technology is, what it is capable of, and its potential applications. The Technology Transfer Office suggested that the application focus be in the area of security and anti-counterfeit applications. The goal was to provide the private sector with a thorough description of the technology by presenting papers, patents and any other literature in a meaningful context, such as counterfeit prevention.

The very nature of the technology posed a very formidable problem of how to present it in a meaningful way via the WWW. The technology is a phase-only mask made from clear plastic that can be unobtrusively placed anywhere on anything to prevent counterfeiting. How does one present a technology that is invisible to the human eye? The approach taken was to present as much information as possible on the attributes of the technology along with a potential area of commercialization.

A literature search was conducted on the WWW and the library for information relating to the technology, its inventor, and potential applications. Furthermore, Dr. Joseph L.

Horner, the inventor, at Hanscom AFB, Massachusetts was contacted for further information. The literature review showed that no information related to the Binary Phase Only Filter (BPOF) or the more general technology, the Phase Only Filter (POF), existed on the Internet. The closest technology related to the POF found was optical correlation, a very broad category. A search in the library revealed technical papers relating to the POF and authored or co-authored by Dr. Horner. Abstracts of the most relevant papers as identified by us and confirmed by Dr. Horner were placed on the POF home page. Copyright restrictions prevented the inclusion of full-text versions along with diagrams on the Web site. Dr. Horner provided the full-text versions of patents related to the POF. The patents' full text along with the figures and equations were scanned in. In addition, Dr. Horner provided a color photograph of himself, and approved a short biographical statement that we had written.

As part of this effort a layperson's description along with potential security uses, such as credit card or ATM card security, was developed. A series of graphical images were designed showing how POF-based security features can be incorporated on magnetic card technology. A second set of graphical images shows how the POF technology can be used with ATM machines. **Appendix G: POF** contains the examples of pages developed to transfer the POF technology via the WWW.

VI.B. Recommendations

Based upon the work performed in developing the home page for the POF technology and the results from the survey of technology transfer professionals the following recommendations can be made on what needs to be included in order to transfer a technology via the WWW:

- ***Description*** -- understandable to a layperson, but technical enough to be appreciated by those with a technical background.
- ***Technology readiness*** -- a description of how ready the technology is and what needs to be done to make it commercially viable.
- ***Commercial applications*** -- what are some possible applications of this technology.
- ***United States patent information*** -- abstracts or full text along with figures and equations for those technically inclined.
- ***Publications*** -- a listing and abstracts of publications on this technology.
- ***Awards*** -- a listing of any awards received by the development team related to the technology
- ***Inventor(s)*** -- a description of the development team if appropriate.
- ***Contacting the TTO*** -- information on whom to contact for further information on commercializing the technology.

VII. SEARCH ENGINES AND THE DESIGN OF THE ROME LABORATORY WEB SITE

Users of the World Wide Web (WWW) have two choices in finding information on the Web: subject catalogs such as Yahoo and EINet Galaxy, and search engines, such as Alta-Vista and Lycos. The fundamental difference between the two is that subject catalogs depend on humans to perform the cataloging, while search engines perform the cataloging through automated means. Search engines depend on software agents called "robots" or "spiders" that crawl across the Web from one Universal Resource Locator (URL) to another and then automatically index or abstract what was found. The discussion here focuses only on search engines since they rely on automated means of cataloging and indexing Web home pages. For a more detailed discussion of subject catalogs and search engines refer to **Appendix H: Search Engines and Subject Catalogs** or visit URL http://www.sils.umich.edu/~fprefect/matrix/answers.html.

In developing a Web site, such as the one for Rome Laboratory, thought must be given to how the site will be indexed by the various Web search engines. What a search engine considers important when indexing a particular home page may not be what a human being would consider as being important. Given a query, there is the potential that a search engine will return hundreds if not thousands of Web pages of various relevancy. The epitome of success for any Web site developer or Web Master is to have his/her site returned as one of the top ten results in the majority of the popular Web search engines for a query that his/her site provides the answer to. In many cases the lack of understanding how the various search

engines index a site causes a site not to appear in the top ten or even in the top twenty. For example, Alta-Vista indexes every word on a page. Lycos' index is built with only selected words, such as the title, the headings, and the most significant 100 words. These differences contribute to the very different result sets that are returned by different search engines for the same query.

A key question, therefore, for any Web master is why are some pages making it to the top of the list while others are not? More important, why is the Web master's own Web page not making it to the top of the list for those queries that it should? The answer lies in how different search engines catalog and index the pages found on the WWW. Also, the difference lies in the algorithms used by the search engines to score relevant pages in the database.

In this section we present a brief overview of search engines to gain an understanding of how they operate. This includes information on how they index a page and how the scores for relevant documents are computed. The information is based on information provided at the respective search engines' Web sites. The amount of information provided varies from site to site, with Alta-Vista providing comprehensive information and OpenText providing hardly any.

The authors also address how a home page can be enhanced in order for it to be returned in the top ten results for queries directly relating to the Web site. An experiment was performed by visiting the major search engines (Alta-Vista, Excite, InfoSeek, Lycos, OpenText, WebCrawler) and running a query with the keywords "Rome Laboratory". Would

the pages returned be from the Rome Laboratory Web-site or from other sites linking to Rome Laboratory?

Through the course of the experiment the authors learned that two search engines (Alta-Vista and WebCrawler) allow the user to surf the Web backwards. In other words, finding all the sites that provide a link back to a particular site. The authors believed that it would be of interest to see what sites provide a link back to Rome Laboratory.

Based on the review and the results of the experiment recommendations are given on how to enhance important Rome Laboratory home pages for automated indexing by the various search engines

VII.A. Introduction to Search Engines

Web search engines attempt to build a detailed catalog of the Web using automated software agents. These software agents are aptly named "spiders" or "crawlers" for they traverse the Web by crawling across the Web from one Uniform Resource Locator (URL) to another collecting other URLs.

What search engines then do with the URLs differs depending on the search engine. Some search engines attempt to record and index the full text of every page. Others only catalog the most popular sites by checking how many links there are to the site. Still others develop an abstract of the page according to some algorithm. How search engines catalog and index sites impacts the search results returned. When a query is presented to a search engine, the search engine's catalogue or index is searched for the query terms. Not all search engines

offer the same search options. Some of the engines use 'OR' as the default and rely on relevancy ranking algorithms to find and rank relevant documents. Other search engines offer a choice between 'AND', 'OR', 'ADJACENT', 'NEAR', and 'NOT' options. More sophisticated search engines such as InfoSeek and OpenText, offer concept searching and phrase searching. The available options are usually detailed in help pages associated with each search engine. An excellent list of attributes and features of subject catalogs and search engines is included in **Appendix I: Search Engine Features** (http://www.sils.umich.edu/~fprefect/matrix/overview.html).

VII.B. The Experiment

In this section the authors review the experiment of running the query "Rome Laboratory" on six major search engines (Alta-Vista, Excite, InfoSeek, Lycos, OpenText, WebCrawler). Brief descriptions on how a particular search engine indexes Web pages and how the relevant documents are scored when a query is posed is provided based on information available at the particular search engine's Web site. A more detailed description of these search engines is provided in **Appendix J: Search Engine Review** (http://www.sils.umich.edu/~fprefect/matrix/).

Of interest was the type of pages returned and whether they were from the RL Web site. Would the pages returned be from the Rome Laboratory Web-site or from other sites linking to Rome Laboratory?

- Of those search results that did come from the Rome Laboratory Web-site, what pages are ranked the highest? Are they the most important pages?
- What is the ranking of the following two Rome Laboratory pages:
    1. The main Rome Laboratory homepage
    2. The Technology Transfer homepage

In conducting the query the default settings for each search engine were used. The keywords "Rome Laboratory" were typed in without using any advanced functions, operators, or changing any of the options that may be present on the query form. The object was to mimic what we believe the majority of people do when they visit a search engine. Most users are not likely to read the directions associated with submitting a more advanced query.

	Rome Laboratory Home Page	Technology Transfer Home Page
Alta-Vista	NF*	NF*
Excite	NF*	19
InfoSeek	17	16
Lycos	NF*	NF*
OpenText	13	NF*
WebCrawler	4	7

* NF denotes that the page was not found in the top thirty returned results

Table 1. Results of Query "Rome Laboratory" Using Six Search Engines

VII.B.1. Alta-Vista

VII.B.1.A. Description

Alta-Vista is the most comprehensive search engine on the WWW. It claims to have 30 million fully indexed pages in its data base. The results returned is a prioritized list of Web pages that contain the words in the query. Each search result is hyperlinked to the actual Web page.

Alta-Vista uses a spider named Scooter to traverse the Web. Digital reports that Scooter can look at over three million Web pages per day and bring back the contents for indexing. Once the pages are collected, all the words on every page are indexed. All the pages at a site are indexed. A user by performing a query can access a page internal to a particular Web site without having to go through the site's main home page.

A document will receive a higher score if:

- the keywords appear in the first few words of the document, especially if it is in the Web page's title or in the heading of USENET news articles
- the keywords are found close to one another in the document
- the document contains more of the keywords than some other document in the database

A Web master for a site can control how the site is indexed. By default, Alta-Vista will index all words in the document excluding comments. The first few words of the document will serve as an abstract that is returned with the search result. Meta-tags can be used to control how the page is indexed.

<META name="description"

content= "Rome Laboratory: "Where Visions Become Reality."

Rome Laboratory emphasizes technology transfer - the sharing or transferring of information, data, hardware, personnel, services, facilities or other scientific resources for the benefit of the private or public sector. At Rome Laboratory our research and development in the areas of signal, speech, and image processing, communications, electromagnetics, photonics, computational sciences, reliability, maintainability, and testability will lead to many future products to greatly benefit both the military and the commercial sectors. Our function at Rome Laboratory is to offer assistance in accessing the technology base at Rome Laboratory and commercializing this technology. ">

<META name="keywords"

content= "Rome Laboratory Federal research technology transfer intellectual property commercial signal speech image processing communications electromagnetics photonics computational sciences reliability maintainability testability Air Force C3I C4I" >

If the above is included in the Technology Transfer homepage, then Alta-Vista will do two things:

1. It will index both fields, so a search with any of the words associated with the content of the two fields will return a match.
2. It will return the description with the URL. In other words, instead of showing the first couple of lines of the page, a match will show the content associated with the meta-tag description.

VII.B.1.B. Query Results

A simple search, the default search, was conducted on Alta-Vista. Of the top thirty results, twelve were from the Rome Laboratory or Directorate Web servers, ten were from other Web sites referring to Rome Laboratory, and eight were from a student's account (http://fang.sunyit.edu) at SUNY Institute of Technology, probably from a class project in 1994. The highest ranking page from the RL server, RL's staff meteorologist Office, came in at number five. The two pages of interest to us in the experiment were not found in the top thirty results. The Technology Transfer request form came in at number twenty-three. A listing of the top thirty results can be found in **Appendix K: Alta-Vista-Query Results**.

VII.B.2. Excite

VII.B.2.A. Description

Excite catalogs pages by full text indexing as well as by concepts describing the page. Abstracts or summaries are automatically generated. They are derived from the text located on the page being indexed. This does not include meta-tags. Preference is also given to punctuated sentences. Using 'concept based' technology Excite's software attempts to determine dominant themes or terms on a page, and then selects the lines for the summary that best contain these terms. These themes are then used as search terms or "keywords" for people to search for while looking for the site.

A user can affect how a document is scored by carefully choosing the wording that appears on a page. A careful wording can make certain concepts and words receive higher emphasis from Excite's software. If the text on the page is concise and to the point it will produce more desirable results than if there are ambiguities on the page. Too little text (i.e., none) will cause Excite's software to go looking through the rest of the Web site to establish summary and keywords. This may or may not produce effective results.

VII.B.2.B. Query Results

Both a keyword search and a search by concept were conducted on the Excite database. The results returned were identical. Of the two pages of interest the Technology Transfer home page was number 19. The main RL home page was not found in the top thirty hits. One drawback in the way Excite returns its results is that it does not give the URLs, thus

making it difficult to tell whether the pages returned are from the RL site or from a site run by an entity working with RL or for RL. Of the top thirty results three results had nothing to do with the Air Force's Rome Laboratory, but with a laboratory located in Rome, Italy dealing with the Romans. A listing of the top thirty results can be found in **Appendix L: Excite-Query Results**.

VII.B.3. InfoSeek

VII.B.3.A. Description

InfoSeek scores search results as follows:

- The score is partly determined by the number of times that a word or phrase appears on the page.
- Searches for common words, such as "computer" and "game", generate lower scores because these words are found in many pages. These words cannot be easily used to distinguish pages containing relevant information.
- Searches for uncommon words, such as "joystick" and "gamepad", generate higher scores because the words do not appear in many pages.
- Searches for phrases (combinations of words), such as "computer game" generate higher scores because the combination of words is not as common as each individual word.

VII.B.3.B. Query Results

Appendix M: InfoSeek-Query Results contains a listing of the top thirty results returned by InfoSeek. The two pages that we were looking for were returned as hit number 16 (RL Technology Transfer) and number 17 (Rome Laboratory Home Page). Of the top ten hits, eight were from the RL Web server. Overall, in the top thirty hits, twenty-seven were from the RL Web server or from Directorate Web servers.

VII.B.4. Lycos

VII.B.4.A. Description

For each page visited Lycos develops an abstract of the page to serve as the page's representation in the search engine. The abstract is derived from what appears in the upper part of the page. If the opening graphic file is an image map, an abstract cannot be taken. If a description or keywords describing the site are part of the image map, then they will be ignored. Good practice is to have important text describing the page or the Web site early on and in addition to any image maps.

VII.B.4.B. Query Results

Appendix N: Lycos-Query Results contains a listing of the top thirty results returned. In these top thirty results none of the two pages of Rome Laboratory that we were looking for were returned. Of the top five results none were from Rome Laboratory. Eight

number 2 is an RL's employee school project that is several years outdated. The other hits were from organizations that are affiliated with Rome Laboratory in some way, such as doing contract work. The rest of the results were mostly from the RL Web server.

VII.B.5. OpenText

VII.B.5.A. Description

Very little can be found at OpenText's site on how this organization indexes Web pages. Open Text's indexing software looks at the first hundred or so words of the Web page and tries to discard the computer code and figures out what is meaningful.

VII.B.5.B. Query Results

OpenText found 848 Web pages containing the keywords "Rome Laboratory". Of the two pages of interest, the Rome Laboratory home page was returned as hit number 13, while the Technology transfer home page was not found in the top thirty. A listing of the top thirty results can be found in **Appendix O: OpenText-Query Results**.

VII.B.6. WebCrawler

VII.B.6.A. Description

WebCrawler computes the relevance score for a particular document by considering how many times the terms in the query occur in the document. The more frequently a word appears in the document, the more relevant the document is judged to be. Another consideration is how unique to the document a given search word is. If the word occurs in only a few documents, its occurrence in a particular document makes it more relevant.

VII.B.6.B. Query Results

For the query "Rome Laboratory" a total of 24,847 documents were found. **Appendix P: WebCrawler-Query Results** contains a listing of the first thirty hits. Of the two pages of interest, the Rome Laboratory home page was returned as hit number 4, and the Technology Transfer home page was returned as hit number 7. Of the top ten results all results were from either the main RL Web server or from Directorate Web servers.

VII.C. Surfing the Web Backwards

VII.C.1. Alta-Vista

Alta-Vista allows a user to surf the Web backwards. In other words, find sites that provide a link to your site. The information to do this is found at URL (http://alta-vista.com/cgi-bin/query?pg=tips)

Find all links to one's site, excluding pages from one's own site the user should type:

- in the **Simple query** +link:http://my.site.com/ -url:http://my.site.com/
- in the **Advanced query** link:http://my.site.com/ AND NOT url:http://my.site.com/

VII.C.1.A. Results of Surfing the Web Backwards

Over 3,000 matches were found. **Appendix Q: Results of Surfing the Web Backwards: Alta-Vista** contains a printout of the first fifty results. The sites providing a link to Rome Laboratory span the gamut from government sites to compilation sites maintained by individuals of various interests. The snowball camera at Rome Laboratory is a popular feature on the Web. While it may not add directly to the scientific work being done at Rome Laboratory, it does, however, bring Rome Laboratory to the attention of Web surfers who may not know about Rome Laboratory's existence.

The 3,000 results were then ranked by the term technology transfer to see which sites in the field of technology transfer provide a link to Rome Laboratory. There were 106 such links. **Appendix R: Surfing the Web Backwards Results Ordered By -- "Technology Transfer"** contains a listing of the first 60 links. The results show that Rome Laboratory is linked to from the major Technology Transfer sites on the Web.

VII.C.2. WebCrawler

WebCrawler allows the user to see what sites provide a link to a particular case. This feature is found at URL (http://www.webcrawler.com/WebCrawler/Links.html). There were 60 documents in the WebCrawler database that had links to Rome Laboratory's URL. **Appendix S: Results of Surfing the Web Backwards: WebCrawler** contains a listing of these sites. The listing is ordered by the popularity of the site. Rome Laboratory's snowball camera is ranked at the top. This once again reinforces the point that the snowball camera was an excellent idea to publicize Rome Laboratory's Web site.

VII.D. Recommendations

Based upon the information provided at the various search engine sites on how they index or abstract pages and on the scoring of pages given a query, the following recommendation can be made:

- Include a descriptive paragraph informing the user what the page or the site is about at the top of the page.
- Repeat keywords or concepts often in the descriptive paragraph. The paragraph ought to consist of complete sentences.

- Do **not** repeat a set of words over and over because this may generate an abstract that is quite uninformative when returned as a result. Some search engines have been programmed to ignore such tactics.
- Include the descriptive paragraph also in a meta-tag called description that is not seen, but some search engines make use of them. More search engines may use them in the future.
- Include a set of keywords in a meta-tag of the name keywords. The page will then be indexed on these keywords.

VIII. RL WEB SITE USAGE STATISTICS

VIII.A. Who Accesses What

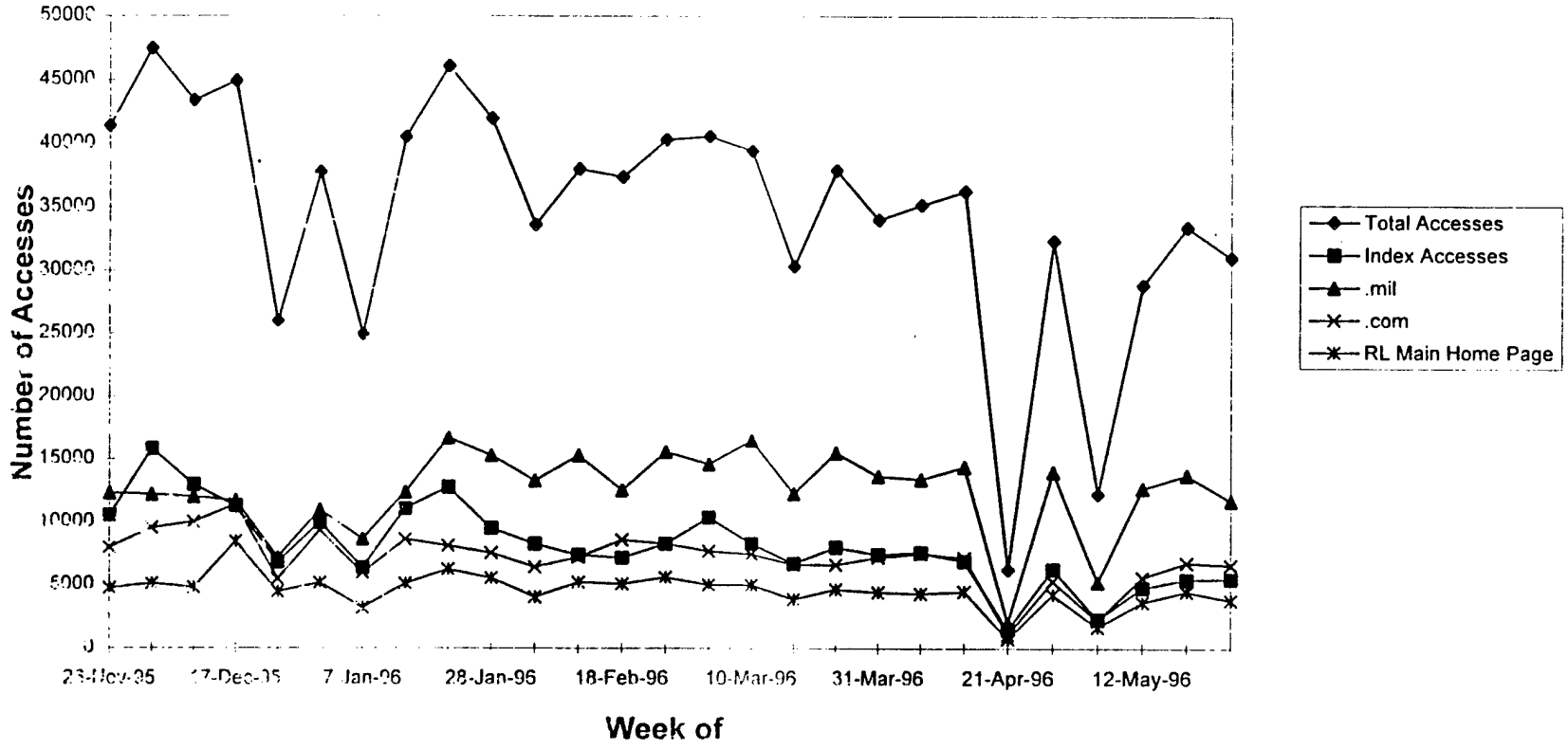
Statistics on accesses to the Rome Laboratory Web site were available for the period November 16, 1995, through May 26, 1996. A graphical representation of the number of various types of accesses is depicted in Figure 6. Of the plots the one labeled RL main home page is the most telling. This line represents the number of times that the main Rome Laboratory home page was accessed. This can serve as somewhat of a crude estimate of the number of different accesses to the Web site. On the average the main page is accessed 4,600 times during a week. The other plots represent the total number of pages accessed.

By examining the log of a typical week more insight can be obtained on who visits the Rome Laboratory Web site (Table 2). In a typical week, on the average, 450 unique commercial organizations visit the RL Web site. Over 240 unique educational domains visit the RL Web site. A third (34) of all the unique domains (115) from the military accessing the RL site comes from Rome Laboratory. Closer examination reveals that the vast majority of the accesses and byte traffic generated by the military domain come from Rome Laboratory. This shows that the RL Web site is being accepted functionally as an intranet by RL employees. The RL intranet is becoming a valuable resource internally at RL.

	.com	.edu	.mil	foreign countries
Unique Visitors	450	240	115*	50
			*(34 from RL)	

Table 2. Visitors to the Rome Laboratory Web Site for a Typical Week

FIG. 6 RL WWW Accesses



Examination of the log files can also reveal who is accessing what. This is extremely important in regard to technology transfer. The TTO office can use to this information to see what sections of the Web site are visited most often and which are not. This can serve as feedback from the user community on what is working well and what needs improvement.

Moreover, the examination of the logs can reveal which companies are interested in which technology. The TTO can keep track and see if a pattern develops on the types of technologies a particular company is interested in. Knowing this, the TTO can then channel to the company information about technological advances at RL that is in the company's sphere of interest. For example, during one week twenty-four requests about the SpeakEasy technology were submitted. Any new developments in this technology could be brought to the attention of these organizations. Institutionalizing such processes would reflect a user-orientation and would mean a clever, continuous and timely customer-needs orientation.

Table 3. shows the Technology Transfer sections that are most often visited for a typical week.

Technology Transfer Sections of Interest	Number of Requests
Tech Transfer home page	130
Past Accomplishments	49
Ads	12
CRDA	16
RL Datasheets	30
Demos-SpeakEasy	24
RL Patents	55
SBIR	44
Technology Payoffs	66

Table 3. RL Technology Transfer Sections Most Often Visited for a Typical Week

On average the Technology Transfer site of the RL Web site receives 130 hits during the course of a week. As expected information on laboratory technology such as *RL Datasheets* and *RL Patents* is highly requested. The notable finding is the interest in RL's past successful technology transfers as illustrated by the number of requests to *Past Accomplishments* and *Technology Payoffs*.

VIII.B. Recommendations

The TTO should take advantage of the information in the log files of the RL Web site. Using a software package such as *WWWSTAT* the TTO at RL can glean a considerable amount of information on who is accessing what. This information can serve (a) strategic and (b) feedback purposes. The information can be used strategically by compiling a list of companies that are interested in particular technologies and then contacting them when there is breaking news in technology that is in the company's sphere of interest. Also, by examining who is not accessing the Web site the TTO can take steps to heightened companies' awareness of the Web site.

The information gleaned from the logs can serve as feedback as to what sections are visited most often and thus reinforcing the importance of making sure that the site is up-to-date with the latest information. Furthermore, it adds a check on what is working on the Web site and what needs improvement. Corrective measures can then be taken.

IX. CLERICAL STAFF GUIDE TO RESOURCES ON WEB DESIGN

For Rome Laboratory's Technology Transfer Web site to be of use it must be frequently updated. Clerical staff must be able to do routine updating of already designed pages as part of their normal routine. Updating of already created pages is not difficult once the basics are mastered and specific features have been designed already. The best way to learn is by reading a basic primer, looking at the HTML code of existing pages, and experimenting.

The WWW and the tools used for it are changing all the time and that is why it is difficult to write a comprehensive manual on how to do things. As Web technology advances and HTML conversion and editing become standard in word processing packages, the modification and creation of Web pages will be greatly simplified. The best information can be found on-line on the Web. For a primer the authors suggest the user visits the Netscape home page (http://home.netscape.com) for the latest information on the WWW and related technologies. On Netscape's home page a link to information on creating Web sites (http://home.netscape.com/assist/net_sites/index.html). A particularly useful primer for clerical staff on the basics is at URL (http://www.ncsa.uiuc.edu/General/Internet/WWW/HTMLPrimer.html). A copy is included in **Appendix T: HTML Primer**.

IX.A. Modifying an Existing Web Page

Several HTML editors exist on the market for the various computing platforms (http://www.yahoo.com/Computers/World_Wide_Web/HTML_Editors/). The simplest way to modify an existing Web page is to either use a text editor or a word processor. A Web page is essentially an ASCII or text document containing text and HTML tags. The HTML tags are the actual formatting commands that tell a browser such as Netscape, how to display the page.

The first step is to open a currently existing HTML file using a text editor or a word processor. When using a word processor it is important to open it as a text or ASCII file. Changes can then be made in the document by typing in the text and the appropriate HTML commands. It is important to remember that the document is not formatted using word processing commands, but using HTML tags. For example, if text is to be bold one has to type the actual HTML tags to bold the text (e.g., <B> text to be bolded. </B>) and not by choosing the bold command in the word processor. When no more changes need to be made the file needs to be saved as an ASCII or text file. Saving in ASCII or text format is extremely important because saving the file in a word processing format, such as Word or WordPerfect, appends various extra formatting and control characters that are unintelligible to the browser.

To view a document as one would see it on the Web while creating it, one must first save the file in ASCII format with the extension html or htm for PCs. Saving in ASCII format is extremely important as mentioned before. Once the document is saved, on some

operating systems one may need to close the file itself before one can view it. On a Macintosh or on a UNIX based systems only a save needs to be performed. On a PC a save and exit of the file must be performed. Always remember to first save the document before attempting to view it. Next, from the menu bar at the top of the page choose *File* and then choose *Open File* and then click on the document to be viewed. This needs to be done only once during a session; other times when the file is already displayed, one just needs click on the *Reload* button at the top of the menu, but of course after saving the file first.

X. CONCLUSIONS / LESSONS LEARNED

X.A. Technology Transfer Via the WWW is Possible

The target audience of private sector technology transfer professionals is ready and willing to use the Internet and the WWW to interact with Rome Laboratory and to learn about new technologies and business opportunities. However, they lament that information currently found on federal laboratories, including RL, is of limited use. They do, however, have high hopes for the future. The fact that most have been exposed to the Web and are using it in some capacity bodes well for the future potential use of the Web for technology transfer purposes. They understand that the WWW can be another channel or perhaps **the** channel for convenient access to and **up-to-date information** about laboratory activities and opportunities. For example, material related to technology transfer but produced by other offices at RL can be linked to from the Technology Transfer section of the Web site

The information on the RL Technology Transfer Web site can help the private sector in its technology transfer activities. Access to routine information will no longer be restricted to business operating hours, but can be accessed any time. The user can access the needed information and delve into it as much as needed. Information, along with the correct points of contact, and information on how to contact, will help in avoiding "phone tag." If the contact is through electronic means, such as a form on the Web page, the requester will then not be limited to business hours to initiate the contact. The latter is especially important if time zones are involved.

The target audience also expressed the desire to have its questions answered quickly. This concern becomes even more pronounced when using electronic mail (e-mail). Those using e-mail expect a quick response to their query. If a quick response is not possible, the TTO at a minimum needs to confirm the receipt of the request by e-mail or, if deemed appropriate, by telephone. At that time further information from the requester can be asked, or an indication given of how long it will take to fulfill the request.

For the TTO, a Web site frees up staff for more constructive people-intensive tasks associated with technology transfer, rather than answering routine questions that could be answered via a Web site. The view expressed by many respondents to the survey was that technology transfer is a person-to-person activity. While a Web site can help in the process, it cannot substitute for people fully of course. However, respondents did express the opinion that a Web site can definitely improve the information flow between the TTO and them if the site is designed properly. Also, the first person-to-person contact with the TTO regarding a technology can be more productive, because first contact will no longer have to deal with the exchange of routine information that would have already been done electronically. The more "people-to-people" aspects of technology transfer can be focused upon, starting with the first person-to-person contact.

Web site content and keeping it up-to-date is critical in the eyes of the potential user community. Content deemed important by the target audience ought to be easily and readily accessible by them. The initial home page seen by a visitor ought to provide links to the information most pertinent to the audience. The visitor to the Web site should not have to

trudge through page after page or have a complete understanding of the organization's departments or directorates in order to locate the desired information. This also holds true for federal laboratory Web sites such as Rome Laboratory. A visitor coming to the RL Web site should not have to know what technology is associated with what directorate. Content needs to be organized by technology with the appropriate hyperlink to more detailed information. If the content most desired is not easily locatable, then the WWW site will serve no purpose in promoting and enhancing interaction between the laboratory and the private sector.

X.B. What Is to Be Included on the Technology Transfer Home Page

Based on respondents' comments, links to the following topics ought to be found on the main technology transfer home page:

- Technology news focusing on current laboratory technology making the news
- Technology data base with point of contact
- Expertise data base with point of contact
- Partnering mechanisms such as CRDAs, Educational Partnerships
- Information related to small business programs
- Business opportunity announcements

Of crucial importance is the developing, organizing, and linking of content to reflect the information needs of the user community. Respondents deemed the following information on each technology as important to have:

- ***Description*** -- understandable to a layperson, but technical enough to be appreciated by those with a technical background.
- ***Technology readiness*** -- a description of how ready the technology is and what needs to be done to make it commercially viable.
- ***Commercial applications*** -- what are some possible applications of this technology.
- ***United States patent information*** -- abstracts or full text along with figures and equations for those technically inclined.
- ***Publications*** -- a listing and abstracts of publications on this technology.
- *Awards* -- a listing of any awards received by the development team related to the technology.
- *Inventor(s)* -- a description of the development team if appropriate.
- ***Contacting the TTO*** -- information on whom to contact for further information on commercializing the technology.

This type of information can be readily provided through the Web. However, collection and organization of this information for each and every technology is not a trivial matter. Rome Laboratory can begin to develop this data base by requiring scientists and engineers working on a project to write a short review of their work using the outline presented above. As new technologies are made available, similar descriptions would be placed on the Web.

The overall success of the Web site can only be judged by the degree to which it serves the needs of the intended audience. The guidelines presented here are applicable to the design of

any Web site. In developing a Web site, one needs to keep in mind what its purpose is, who the target audience is, and what information users want to see. This research addressed these issues in the context of building a technology transfer Web site for a federal laboratory targeted to the private sector. The authors' intent was to provide a user-perspective on what a Web site for technology transfer ought to provide. The results presented can help federal laboratories reorganize their Web sites to meet the target audience's needs, thus making a Web site a viable means of conducting technology transfer.

X.C. The Future Vision of Rome Laboratory Web Site

As envisioned by the authors, the Rome Laboratory Technology Transfer Web site ought to be an umbrella Web site covering the various Rome Laboratory Directorate Web sites. The content provided by the various directorates on their respective Web sites are to be the building blocks of the Technology Transfer Web site (Figure 7). In other words, each respective directorate's Web site acts as a repository of what is currently happening in the directorate upon which the TTO office can then draw upon in developing the Technology Transfer portion of the overall Rome Laboratory Web site.

Each directorate would be responsible for developing Web pages describing the various technologies and projects within the directorate. At the operational level each directorate would have a team responsible for developing these pages. Scientists and engineers upon completion of a project would not only be required to submit a final report, but also to submit content to the directorate's Web site development team through the

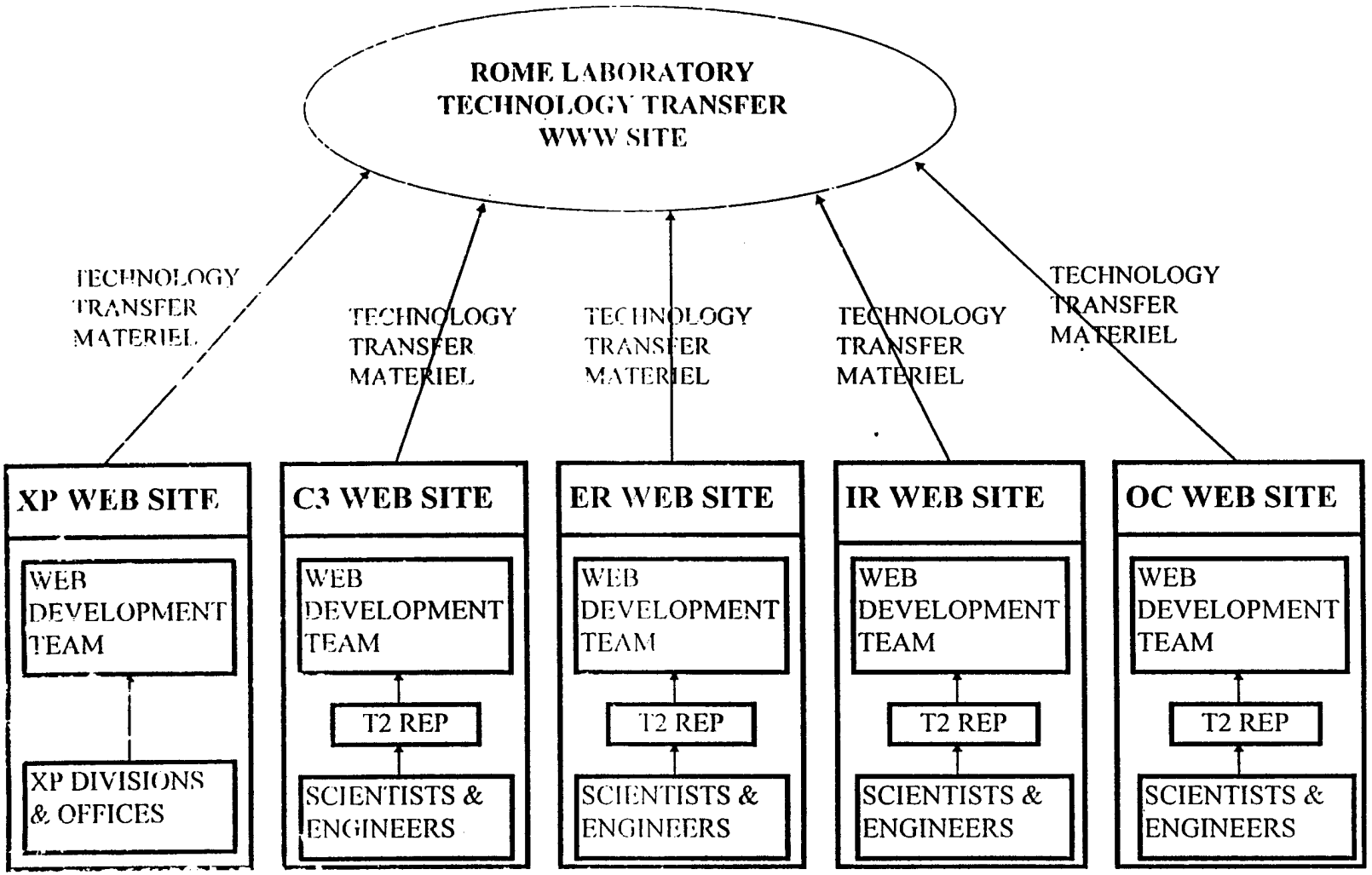


FIG. 7 INFORMATION FLOW TO THE ROME LABORATORY TECHNOLOGY TRANSFER WEB SITE

directorate's T2 representative for placement on the Web. The development of these Web pages would be guided by the TTO office to make sure that each description is consistent and comprehensive, and provides the necessary information for customers in the private sector.

The TTO can draw on this repository in building a Web site devoted to transferring Rome Laboratory technology. The TTO will provide the uniformity so desirable in presenting the Rome Laboratory and its technologies as a unified unit as opposed to four separate directorates.

Lastly, if only one major recommendation had to be made, *minimally for the Web site to be useful in promoting technology transfer it must be kept up-to-date with the appropriate information sought by the private sector.*

V.D. A Virtual Technology Area Marketplace

A next logical progression of the Rome Laboratory Web site is the development of a virtual marketplace for a technology area. A Virtual Technology Market (VTM) will bring together researchers, industry, government agencies, and users interested in the technology area. VTM will facilitate communication and technology transfer between research providers, research users, and industry by bringing together all the stakeholders.

VTM will allow stakeholders to (a) seek help in solving problems, (b) offer solutions to problems, (c) offer new technologies and innovations to others, and (d) provide information on the research frontier.

Expected users will include people from industry, academia, and government who are involved in the development and application of this technology. The VTM will provide information on operational requirements, identification, evaluation, developments, demonstrations and assessments on new or improved technology applications. VTM will also provide assessment in the technology area of new products, standards and testing via the WWW.

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XII. APPENDIX

Appendix A:
Survey-Questionnaire

SYRACUSE UNIVERSITY

SCHOOL OF INFORMATION STUDIES

February 5, 1996

Dear Sir/Madam:

We are continuing to solicit your cooperation in an important research project related to technology transfer. Enclosed is a second copy of a questionnaire we sent you last month focusing on the means by which people such as yourself involved in technology transfer stay current with technology developments at Federal Laboratories. We would again ask you to take 20 minutes to complete and return either this questionnaire or the one you received earlier to us in the enclosed, pre-addressed envelope, as your response is very valuable to our research. Please return the questionnaire by February 21, 1996.

Again, the focus of this study is on finding out whether the Internet or its tools, e.g., the World Wide Web (WWW), Listservs, or USENET newsgroups play any role in helping you with your technology transfer activities. Furthermore, we are in the process of designing a technology transfer website for Rome Laboratory and are seeking input from technology transfer professionals as to the website's content. Our goal is to design a website with content that will help in your efforts of identifying potential technologies for commercialization.

Your response to the enclosed questionnaire is important to the overall success of using the WWW in support of technology transfer. All responses are kept strictly confidential and will only be reported in summary form. The findings, it is hoped, will provide insight on the information needs of technology transfer professionals that can then be served via the WWW. Summarized results will be available to participants of this study upon request.

Of course, participation in this survey is voluntary. Return of the questionnaire will be considered your consent to participate in this study. If you have any questions regarding this questionnaire, please contact me at +315-443-5608 or by e-mail: rwigand@syr.edu.

Thank you for taking the time to respond to this questionnaire. Your cooperation is greatly appreciated.

Sincerely,

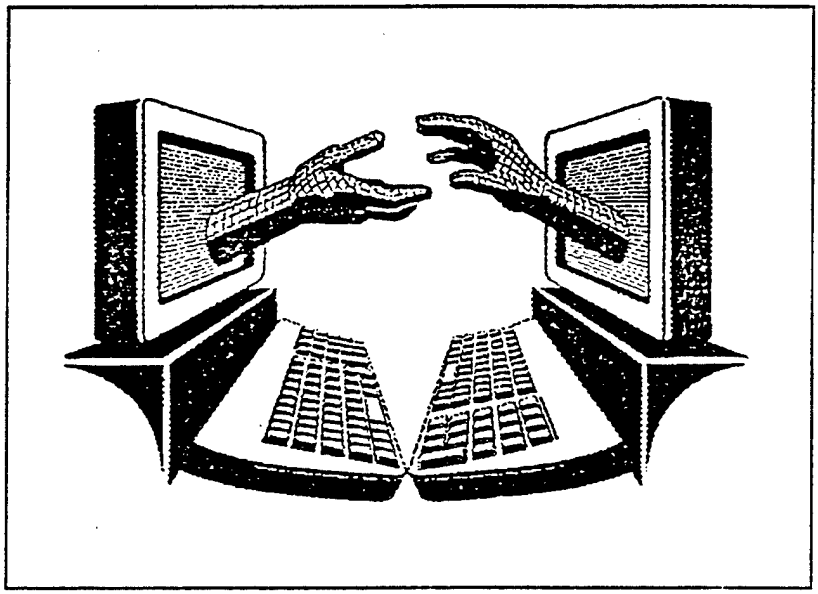
Rolf T. Wigand, Ph.D.
Professor and Director
Graduate Program in Information Resources Management

Encls.: 1 questionnaire
1 pre-addressed envelope

"A Century of Innovation: 1896 - 1996"

4-116 Center for Science & Technology | Syracuse, New York 13244-4100
315-443-2911 | FAX: 315-443-5806 | E-mail: ist@syr.edu | URL: http://istweb.syr.edu

Technology Transfer and Federal Laboratories



Please return survey to:

Rolf T. Wigand, Ph.D.
School of Information Studies
Syracuse University
4-118 Center for Science and Technology
Syracuse, NY 13244-4100

Technology Transfer and Federal Laboratories

We begin by asking questions concerning how you stay informed about new technology developments at Federal Laboratories.

Q-1 How do you currently gather information about new technology developments at particular Federal Laboratories? *Check the box for all that apply, and list other methods.*

- ☐ 1. Via Federal Laboratory produced brochures
- ☐ 2. Via publications (please specify: _____)
- ☐ 3. At conferences
- ☐ 4. By telephone
- ☐ 5. Electronically (e-mail, Internet)
- ☐ 6. Other (*Please Specify:* _____)
- ☐ 7. Other (*Please Specify:* _____)
- ☐ 8. Other (*Please Specify:* _____)
- ☐ 9. Other (*Please Specify:* _____)

Q-2 Referring to question 1 (Q-1), which of the above means of collecting information about new technologies do you consider most, second most, and third most important? *Write the number of the item from Q-1 on the appropriate line below.*

_____ Most important _____ Second most important _____ Third most important

This section asks about your interactions with Federal Laboratory Technology Transfer Offices.

Q-3 Categorize the type of technology transfer information that you most request. Are your requests most often: *Check the appropriate answer.*

- ☐ General in nature such as trying to collect data for a new business area your company is trying to get into?
- ☐ Specific in nature such as trying to solve a specific technical problem or improve an existing process?

Q-4 What is (are) your chief method(s) of keeping contact with a Federal Laboratory's Technology Transfer Office? *List all methods you use.*

Q-5 How often do you contact a Federal Laboratory's Technology Transfer Office?

Q-6 In order to do your job effectively, what information provided by the Technology Transfer Office is most important to you?

Q-7 In order to do your job more effectively, what additional information would you like the Technology Transfer Office to provide you with? *List all you can think of.*

Q-8 What are some of the barriers, if any, that you have encountered when dealing with a Technology Transfer Office? *List all you can think of.*

Q-9 Do you feel that there is a need for improved information exchange between Federal Laboratory Technology Transfer Offices and the private sector? *Using the scale below, please check the box that reflects your belief.*

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree

Q-9a If you agree, how then would you improve the process of exchanging information? *Use the back page if needed.*

Q-10 Would you be willing to complete and electronically return an inquiry form which provides the Federal Laboratory with some background information on your company and a short description of your inquiry before actually speaking with a T2 representative? *Check the appropriate box*

☐ Yes ☐ No

If No, please explain why?

Q-11 Much has been written lately in the popular press about the Internet and related tools. Please indicate how strongly you agree or disagree with the following statement,

"The following Internet tool, (*insert the name of the tool from the chart below here*), will improve communication between Federal Laboratories and the private sector involved in the technology transfer process."

Using the scale below, please check the box that reflects your degree of agreement with the above statement for each tool.

Internet Tool	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
• Electronic mail	☐	☐	☐	☐	☐
• File Transfer Protocol (FTP)	☐	☐	☐	☐	☐
• Gopher	☐	☐	☐	☐	☐
• Listservs	☐	☐	☐	☐	☐
• USENET newsgroups	☐	☐	☐	☐	☐
• World Wide Web (WWW)	☐	☐	☐	☐	☐

Next, we would like to ask you some questions on your Internet usage, not including the World Wide Web (WWW).

Q-12 Do you have access to the Internet, **not** including the WWW?

☐ Yes ☐ No

~ If you answered YES to question Q-12, proceed to question Q-12c. ~

~ If you answered NO to question Q-12, proceed to question Q-12a. ~

Q-12a Do you or does your organization intend to get access to the Internet?

☐ Yes ☐ No

Q-12b If yes, in what time frame?

_____ Enter number of months, or enter Don't Know.

~ Skip to question Q-13 of the survey. ~

Q-12c How long have you been using the Internet, **not** including the WWW?
Check the appropriate answer.

☐ 1. 6 months or less
☐ 2. More than 6 months, but less than 1 year
☐ 3. A year, but less than 2 years
☐ 4. 2 to 5 years
☐ 5. More than 5 years

Q-12d What do you use the Internet (**not** including the WWW) for? *Check all that apply.*

- ☐ 1. E-Mail
- ☐ 2. General Browsing
- ☐ 3. Searching for Specific Information
- ☐ 4. FTP / Downloading and File Transfer
- ☐ 5. Other (Please *Specify*) _____

Q-12e Roughly, how much time do you spend on the Internet each week, **not** including WWW time?

_____ Enter hours per week.

Next we would like to ask you some questions only on your World Wide Web (WWW) usage.

Q-13 Do you have access to the WWW?

☐ Yes ☐ No

~ If you answered YES to question Q-13, proceed to question Q-14.~

~ If you answered NO to question Q-13, proceed to question Q-13a.~

Q-13a Do you or does your organization intend to get access to the WWW?

☐ Yes ☐ No

Q-13b If yes, in what time frame?

_____ Enter number of months, or record Don't Know.

~ Skip to question Q-16 of the survey. ~

Q-14 Does your organization have a home page on the World Wide Web (WWW)?

☐ Yes ☐ No

Q-14a If yes, how long has the home page been in existence?

_____ Enter number of months.

Q-15 Do you use the World Wide Web (WWW)?

☐ Yes ☐ No

~ If you answered YES to question Q-15, proceed to Q-15a. ~

~ If you answered NO to question Q-15, proceed to Q-16. ~

Q-15a Roughly, how much time do you spend on the World Wide Web per week?

_____ Enter hours per week.

Q-15b Which browser do you use most frequently? *Please check the appropriate answer.*

- ☐ 1. Lynx
- ☐ 2. Mosaic
- ☐ 3. Netscape
- ☐ 4. Other (*Please Specify*) _____

Q-15c What computing platform do you use? *Please check the appropriate answer.*

☐ 1. PC or compatible ☐ 2. Macintosh
☐ 3. Sun workstation ☐ 4. Other (*Please Specify*) _____

In this section, we focus on your use of Internet Listservs to promote technology transfer.

Q-16 Do you subscribe to any Listservs relating to technology transfer?

☐ Yes ☐ No

~ If you answered YES to question Q-16, proceed to Q-16a. ~

~ If you answered NO to question Q-16, proceed to Q-17. ~

Q-16a What is the chief benefit derived from your subscription to a Listserv? *List benefit and describe it briefly.*

Q-16b How many of the Listservs that you subscribe to can be categorized as being devoted to technology transfer?

_____ Enter number of Listservs.

Q-16c If the answer to question Q-16b is other than NONE, what is the one Listserv devoted to technology transfer that you find most beneficial?

_____ Enter Listserv name.

Q-16d Of the Listservs that you subscribe to, how many can be categorized as being devoted to a specific technology or technology area?

_____ Enter number of Listservs.

Q-16e If the answer to Q-16d is other than NONE, what is the one Listserv devoted to a specific technology or technology area that is most beneficial to you?

_____ Enter Listserv name.

In this section, we focus on your use of USENET newsgroups to promote technology transfer.

Q-17 Do you read any USENET newsgroups relating to technology transfer on a regular basis?

☐ Yes ☐ No

~ If you answered YES to question Q-17, proceed to Q-17a. ~

~ If you answered NO to question Q-17, proceed to Q-18. ~

Q-17a What is the chief benefit which you derive from reading a USENET newsgroup? *List benefit and describe it briefly.*

Q-17b Of the USENET newsgroups that you read on a regular basis, how many can be categorized as being devoted to a general discussion on technology transfer?

_____ Enter number of USENET newsgroups.

Q-17c If the answer to Q-17b is other than NONE, what is the one USENET newsgroup devoted in general to technology transfer that you find most beneficial?

_____ Enter newsgroup name.

Q-17d Of the USENET newsgroups that you read on a regular basis, how many can be categorized as being devoted to a specific technology or technology area?

_____ Enter number of USENET groups.

Q-17e If the answer to Q-17d is other than NONE, what is the one USENET News group devoted to a specific technology or technology area that is most beneficial to you?

_____ Enter newsgroup name.

In this section we focus on your usage of the World Wide Web (WWW) for technology transfer.

Q-18 Do you use the WWW to visit the home pages of Federal Laboratories?

☐ Yes ☐ No

~ If you answered YES to question Q-18, proceed to Q-18a. ~

~ If you answered NO to question Q-18 proceed to Q-21. ~

Q-18a How did you first become aware of Federal Laboratory home pages on the WWW? *Check the appropriate answer.*

☐ Arbitrary browsing of the WWW
☐ Past business activities
☐ Advertisements (*Please Specify*) _____
☐ Trade Shows (*Please Specify*) _____
☐ Other (*Please Specify*) _____

Q-18b What is the primary factor in choosing a Federal Laboratory web site to visit? *Check the appropriate answer.*

- ☐ The Laboratory's mission
- ☐ Geographic proximity to your company
- ☐ Amount of contractual business opportunities
- ☐ Other (*Please Specify*) _____

Q-18c How many **different** Federal Laboratory home pages do you visit in a typical week?

_____ Enter number of different home pages visited.

Q-18d Does visiting a Laboratory's home page help your technology transfer efforts? *Please write a short statement.*

Q-18e At Federal Laboratory websites, which sections are of most interest to you? *Please list and/or describe. Continue on back page if necessary.*

Q-19 Have you ever contacted a Federal Laboratory based on what you had seen at the Laboratory's website?

☐ Yes ☐ No

~ If you answered YES to question Q-19, proceed to Q-19a. ~

~ If you answered NO to question Q-19, proceed to Q-20. ~

Q-19a How many times? .

_____ Enter number of times.

Q-19b How did you contact the Federal Laboratory? *Check all that apply.*

- ☐ 1. Via telephone
- ☐ 2. Via fax
- ☐ 3. Via e-mail
- ☐ 4. Via form provided at the home page
- ☐ 5. Via letter
- ☐ 6. Other (*Please Specify*) _____

Q-19c When you made contact based on WWW information, did you contact the Laboratory's Technology Transfer Office?

☐ Yes ☐ No

Q-19d If NO, then what other entity did you contact at the Laboratory? *Please specify.*

Q-20 Is there one Federal Laboratory website that you visit most often?

☐ Yes ☐ No

~ If you answered YES to question Q-20, proceed to Q-20a. ~

~ If you answered NO to question Q-20, proceed to Q-21. ~

Q-20a Enter name of the Federal Laboratory website or URL visited most often.

_____

Q-20b How frequently do you visit the website?

☐ 1. Daily ☐ 2. Weekly
☐ 3. Monthly ☐ 4. Other (*Please Specify*) _____

Q-20c What in particular makes you come back to the site time after time? *Please write a brief statement. Continue on back page if necessary.*

Q-21 If you were the designer of a Federal Laboratory website, what features or content would you consider indispensable to have on there and why? *Continue on back page if necessary.*

Q-22 Are there any additional comments you would like to make? *Continue on back page if necessary.*

Finally, we would like to ask a few questions about you for statistical purposes.

Q-23 What is your title or position?

Q-24 What are your duties and responsibilities within your organization? *Describe briefly.*

Q-25 How long have you worked:

Q-25a At your present company/organization? _____ Years

Q25b In your current job assignment? _____ Years

Q-26 How many employees does the organization have for which you work?

_____ Enter number of employees in your organization

Q-27 What line of business is your organization in? *Describe briefly.*

Q-28 How would you characterize your organization? *Check the appropriate answer.*

- ☐ For Profit
- ☐ Federal Laboratory
- ☐ Academic
- ☐ Non Profit - Private
- ☐ Government Agency
- ☐ Other (*Please specify*): _____

Q-29 How old are you? *Please check the appropriate age group.*

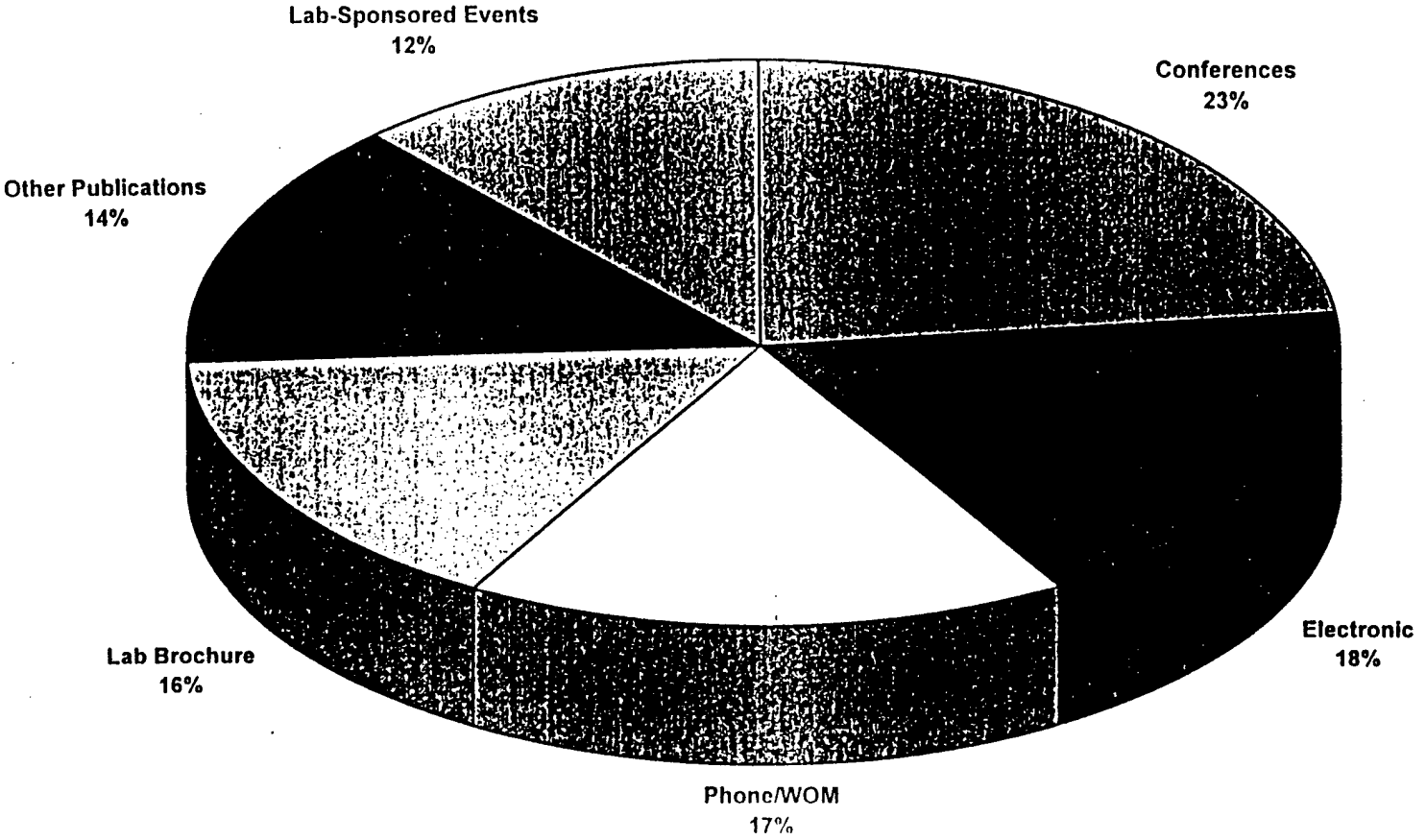
☐ 20 - 29 ☐ 30 - 39 ☐ 40 - 49 ☐ 50 - 59 ☐ 60 or over

NOTE: If you would like to receive a copy of the results of this study, please record your name and mailing address below:

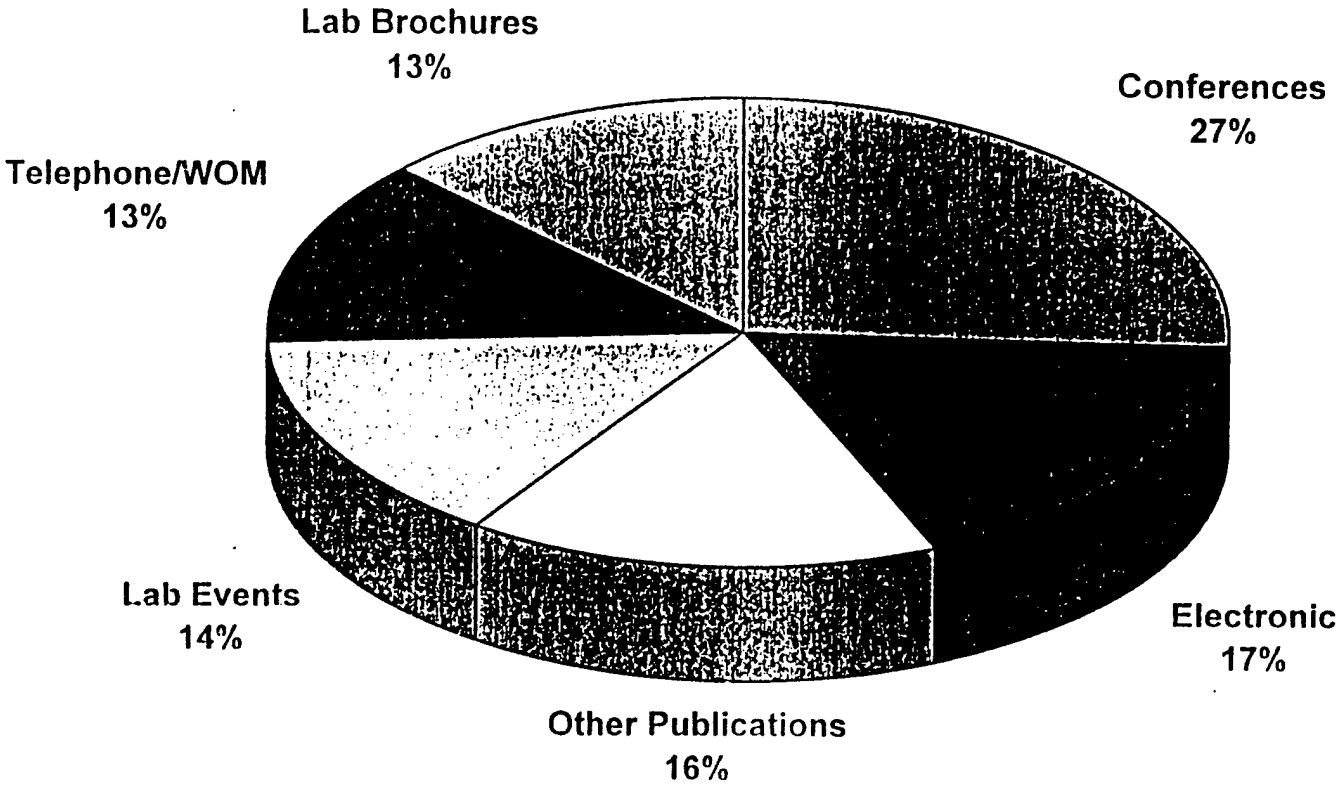
Thank you very much for your time and participation. Please return the completed questionnaire in the enclosed, stamped, addressed envelope and mail it.

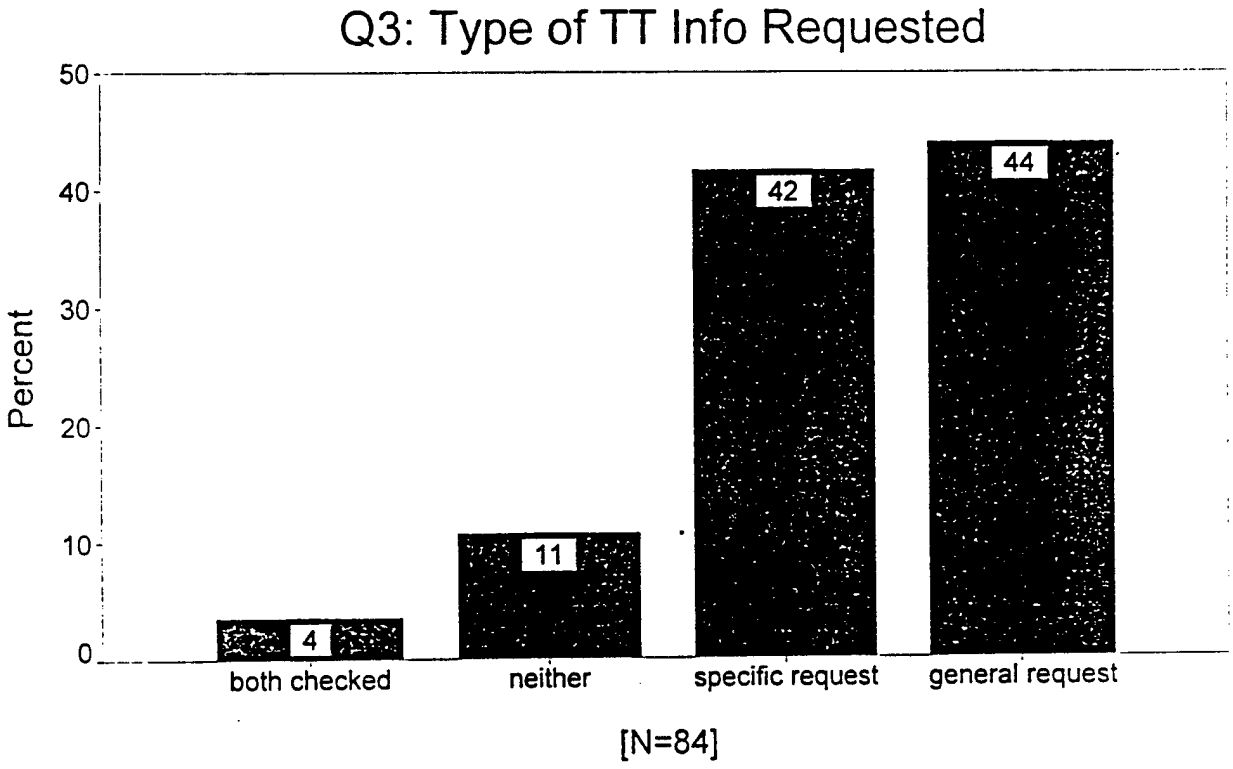
Appendix B:
Survey-Results

Q1: Sources of Info for T2 [N=84]

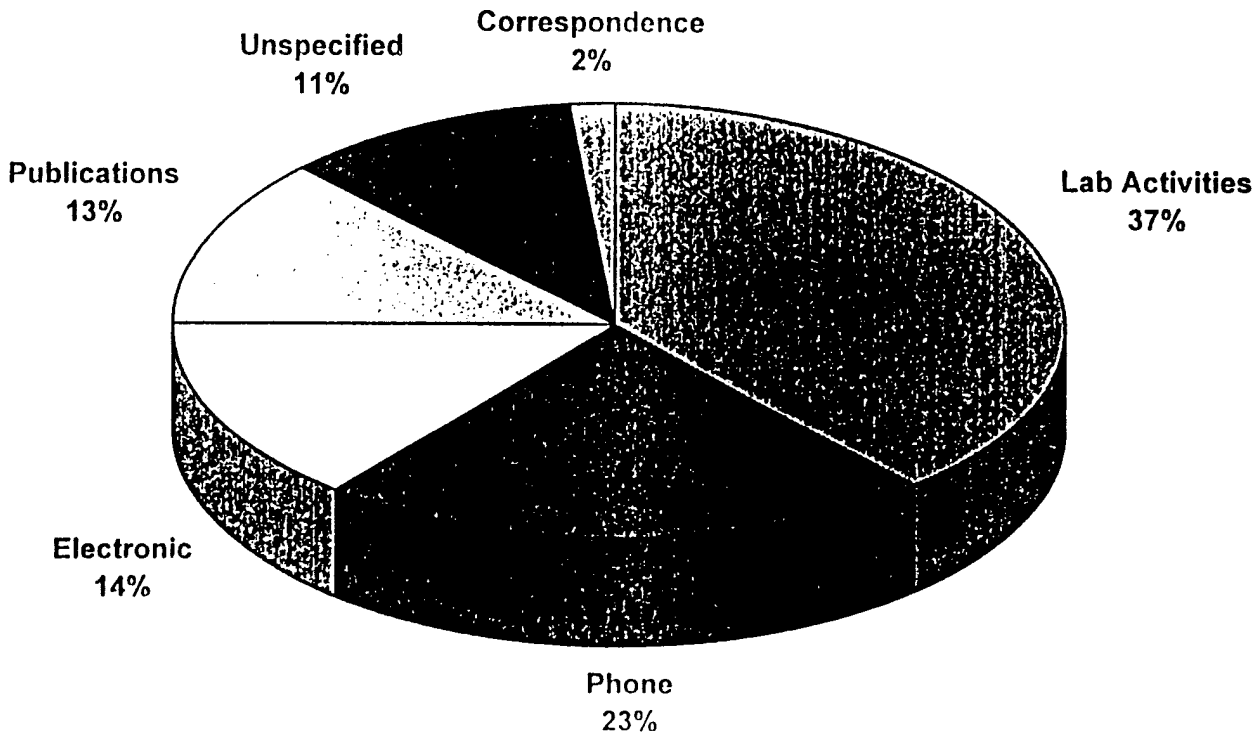


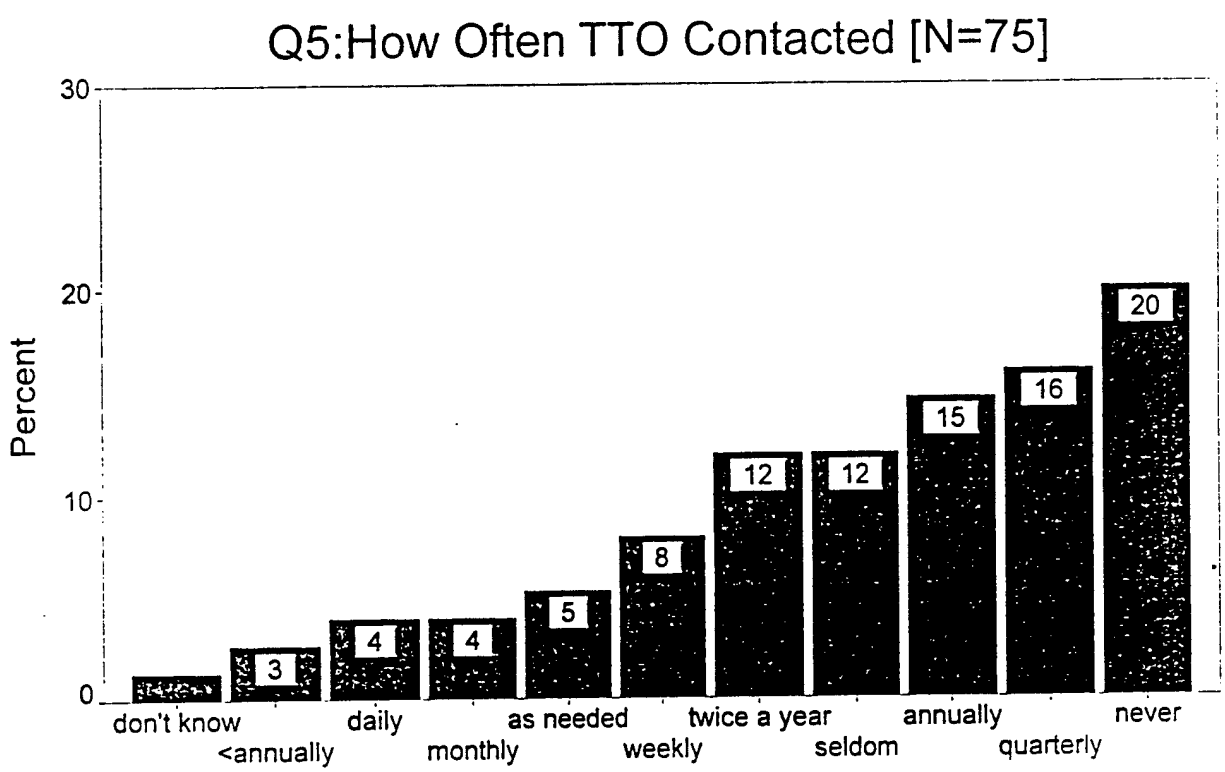
Q2:Perceived Importance of T2 Info Methods [N=82]



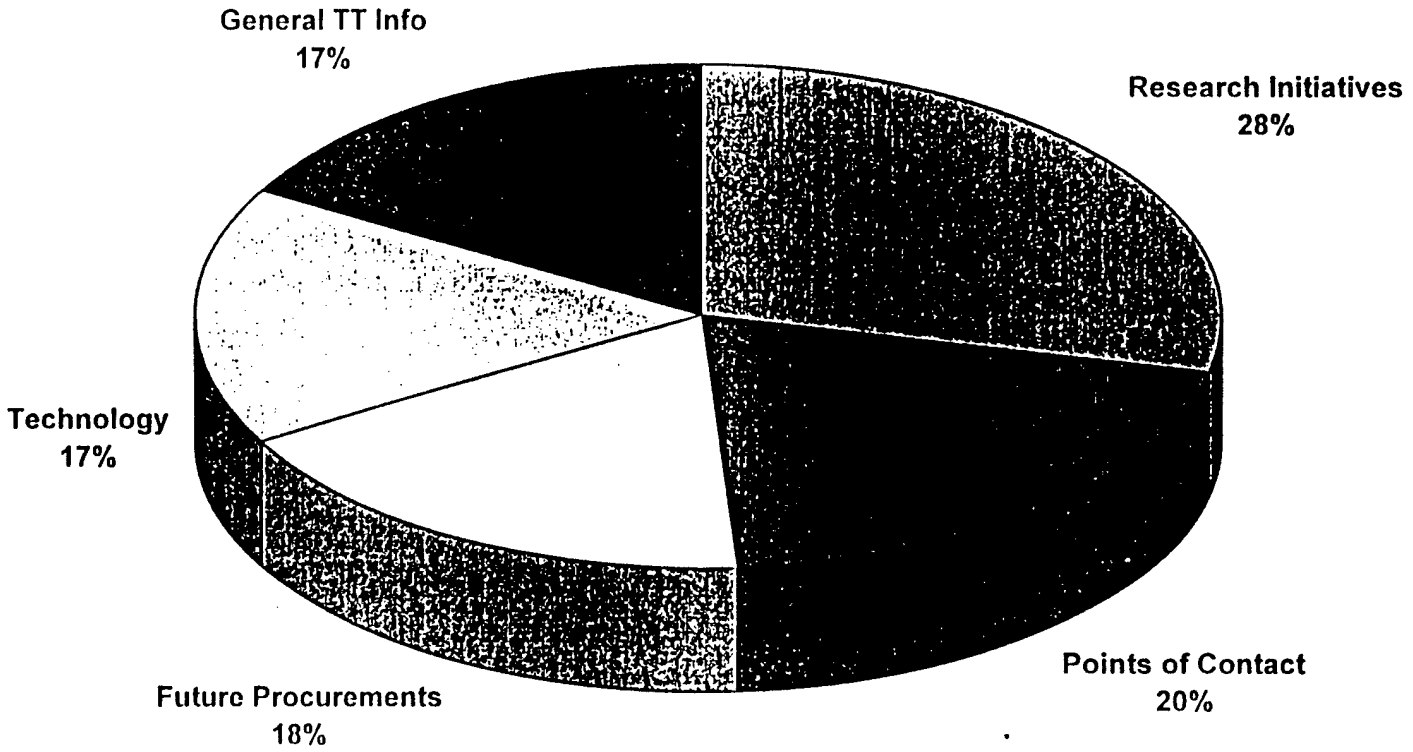

Q3: Type of TT Info Requested
Percent
50
40
30
20
10
0
4
11
42
44
both checked
neither
specific request
general request
[N=84]

Q4:Method of Contacting TTO [N=61]

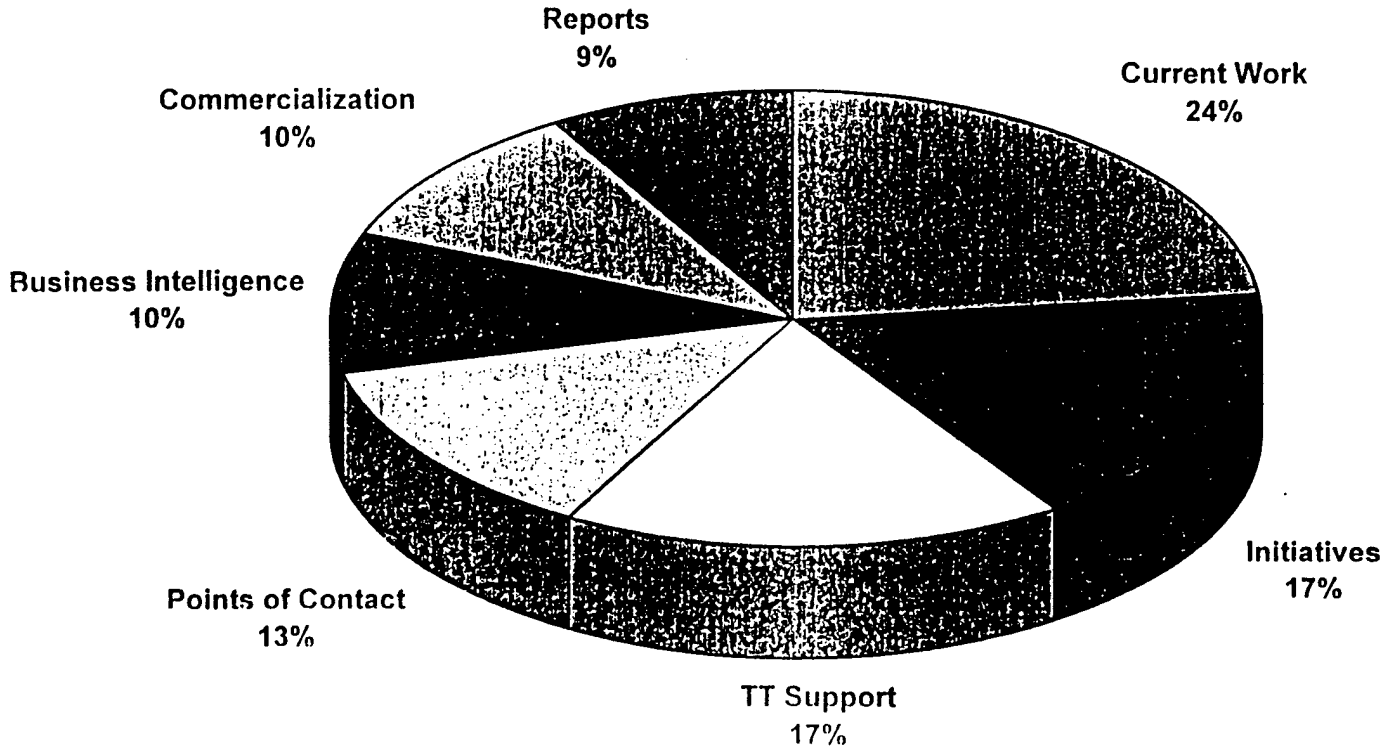



Q5:How Often TTO Contacted [N=75]
Percent
30
20
10
0
3
4
4
5
8
12
12
15
16
20
don't know
<annually
daily
monthly
as needed
weekly
twice a year
seldom
annually
quarterly
never

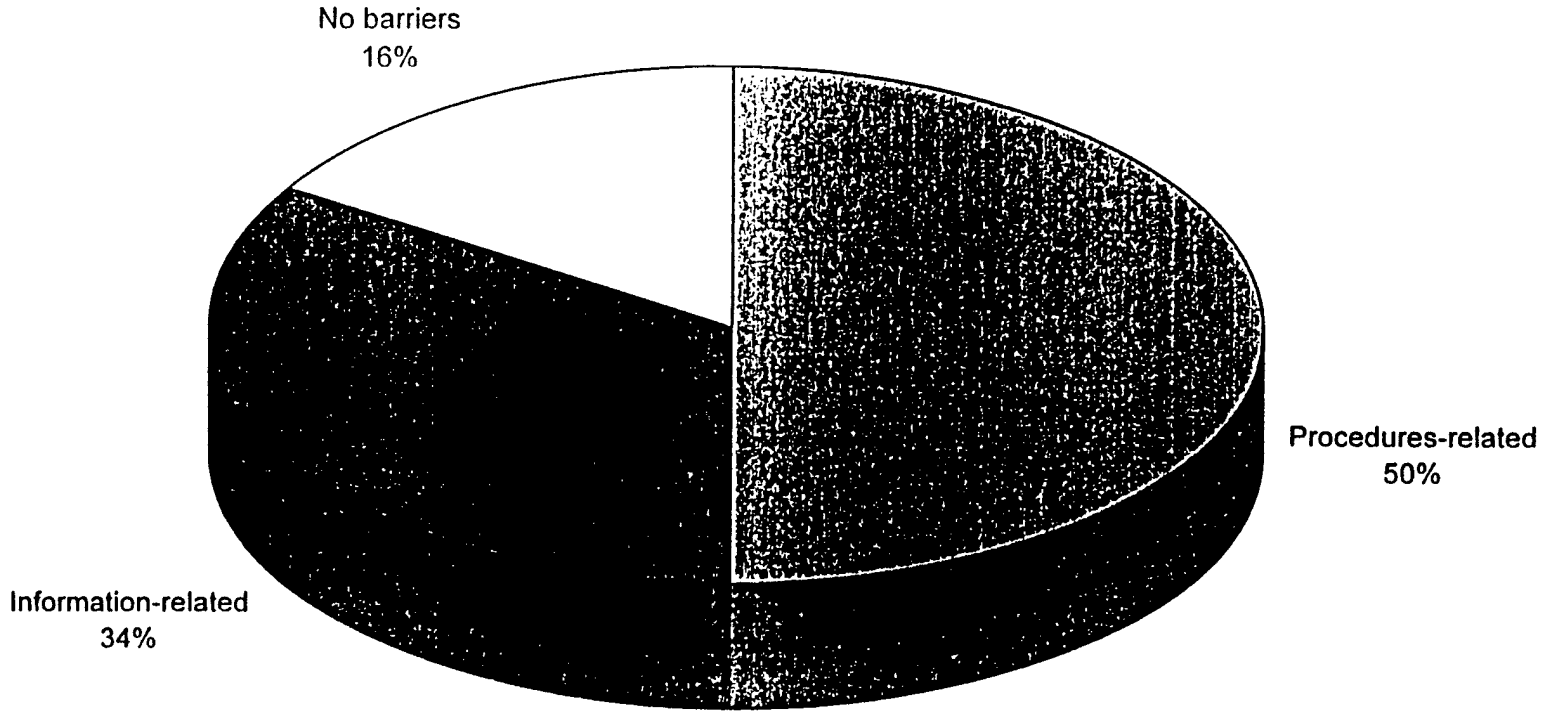
Q6: Key Info TTO Provides [N=67]

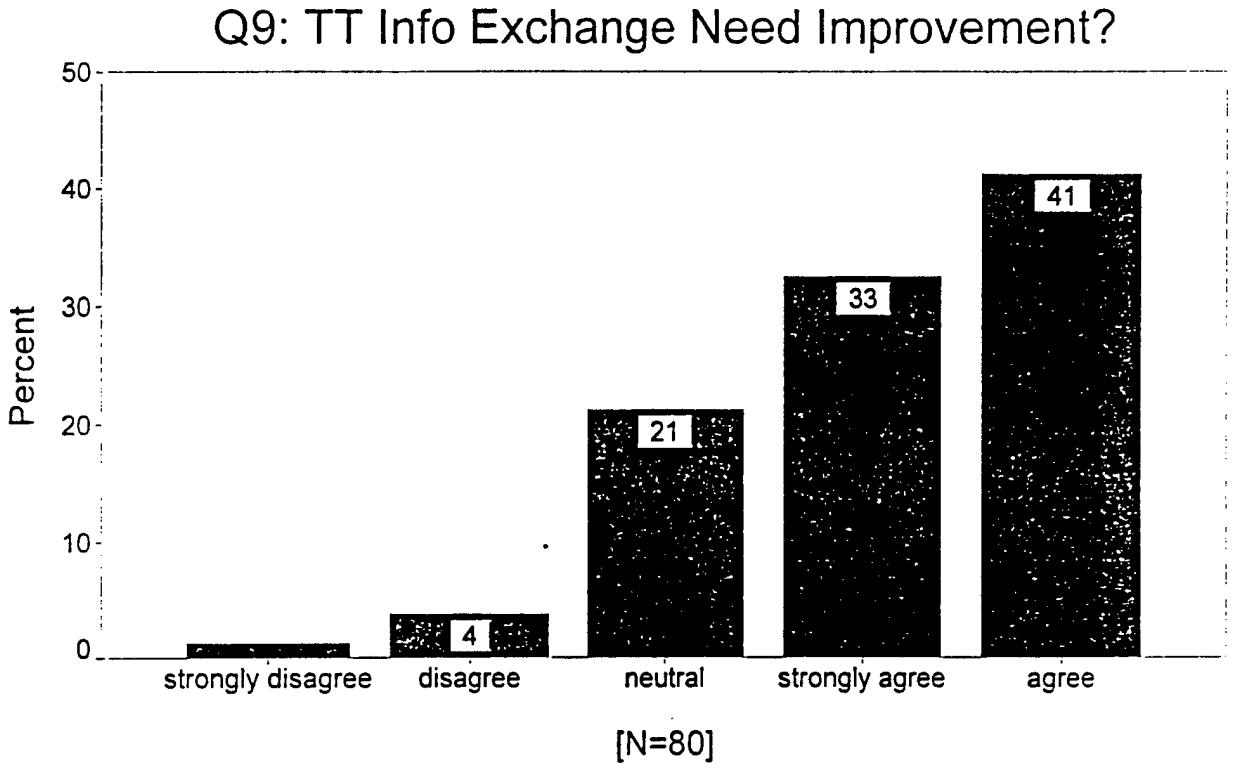


Q7: Additional Info TTO Should Provide [N=48]

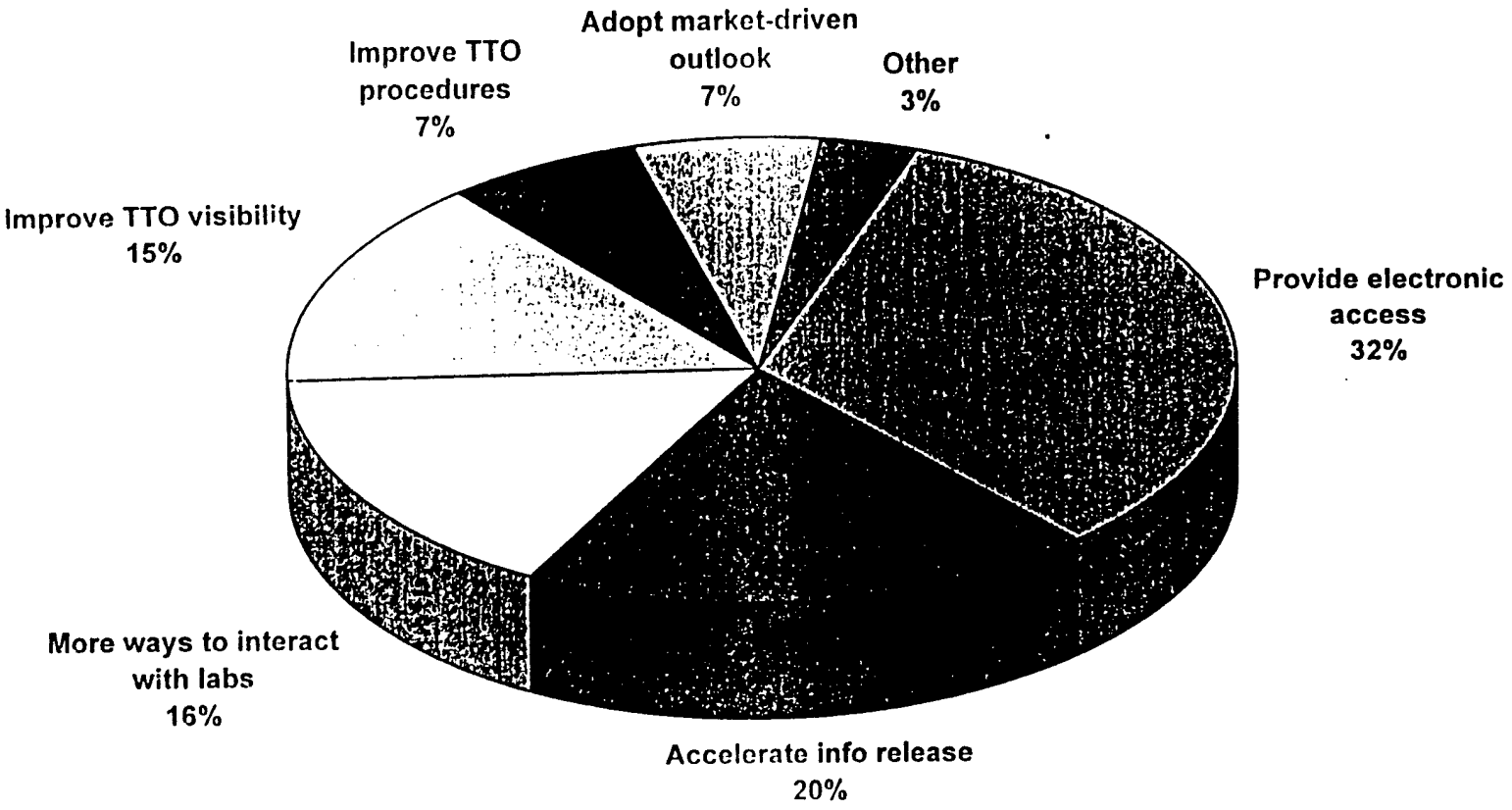


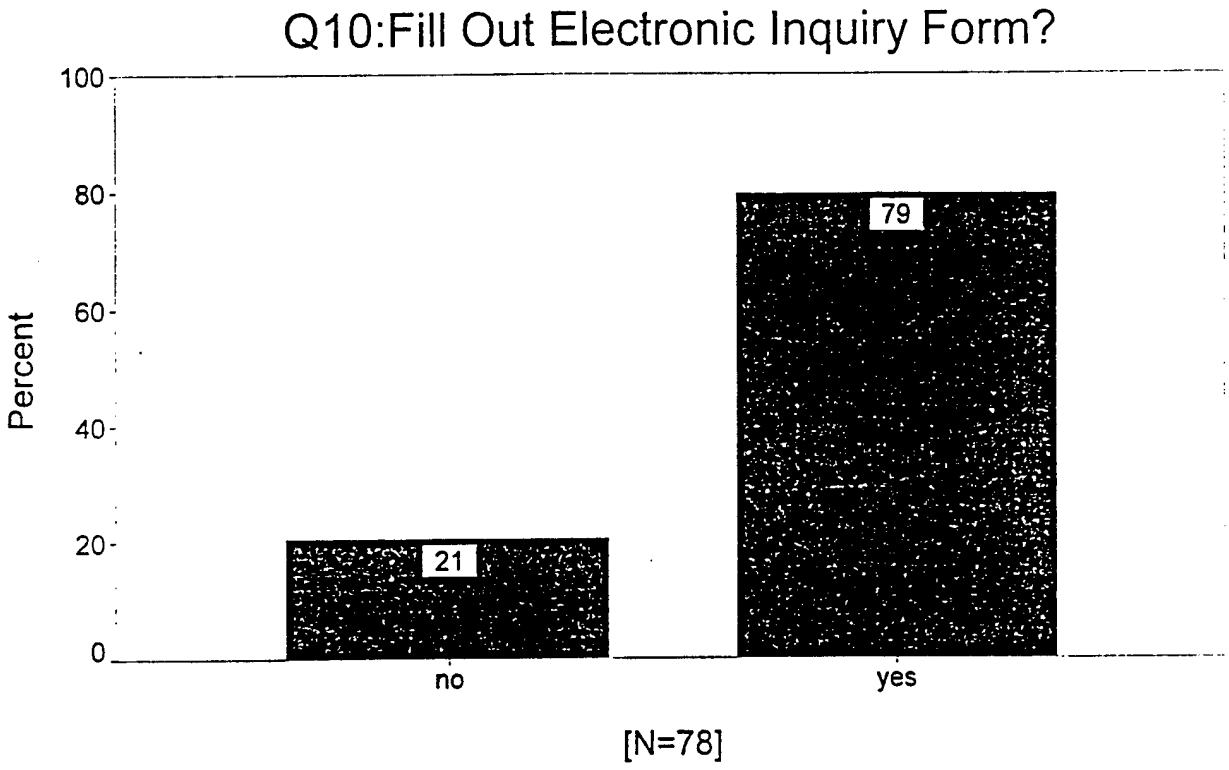
Q8: Barriers to TTO Contact [N=55]



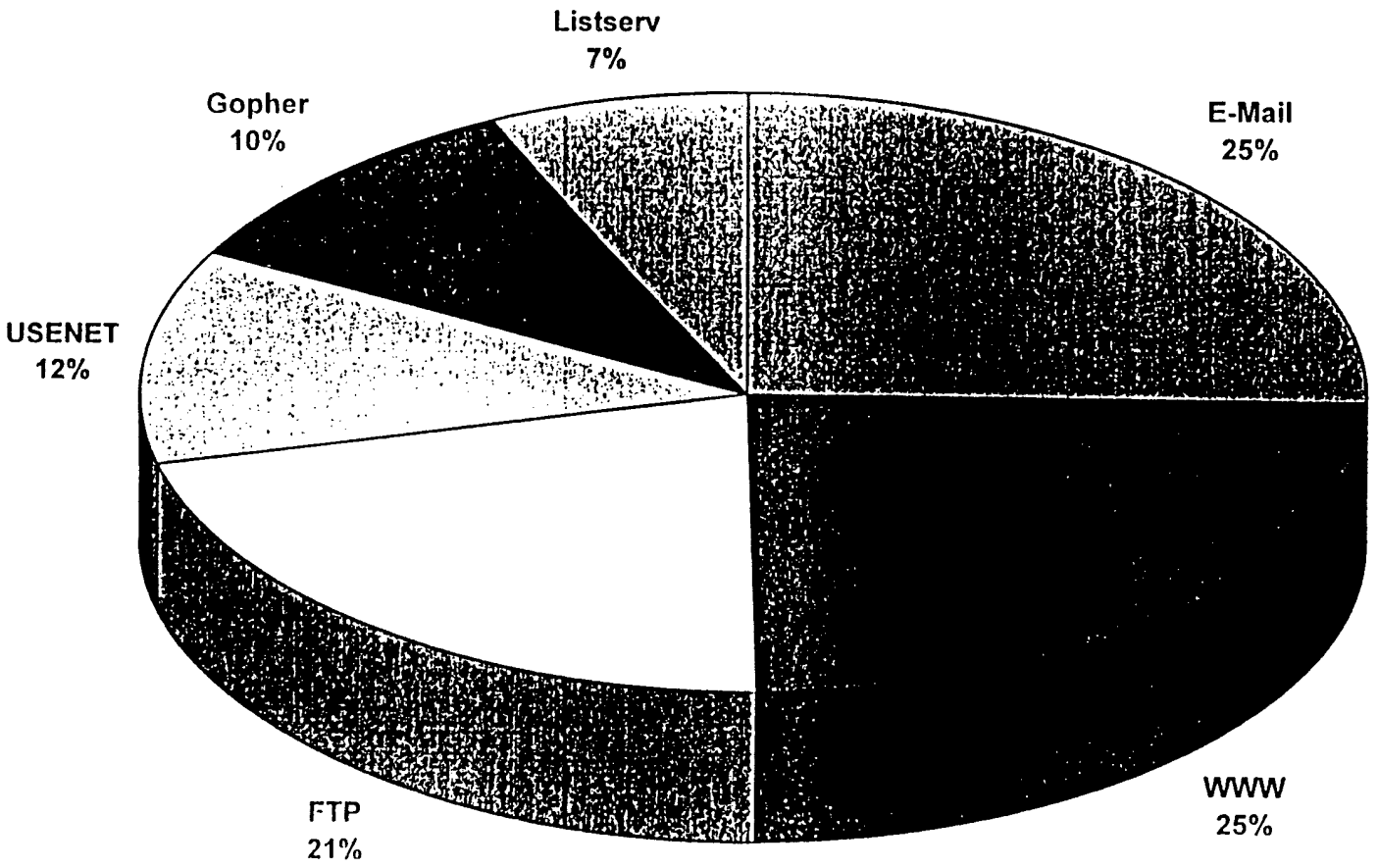

Q9: TT Info Exchange Need Improvement?
Percent
50
40
30
20
10
0
4
21
33
41
strongly disagree
disagree
neutral
strongly agree
agree
[N=80]

Q9A: Info Exchange Improvements [N=50]



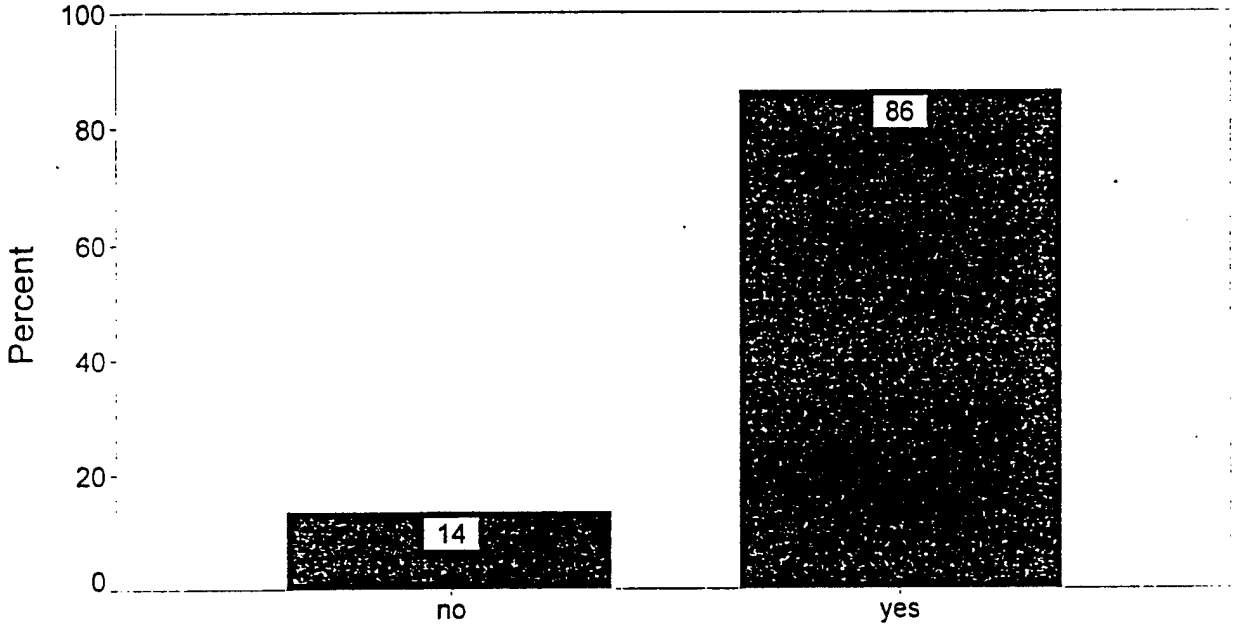

Q10:Fill Out Electronic Inquiry Form?
100
80
60
40
20
0
Percent
21
79
no
yes
[N=78]

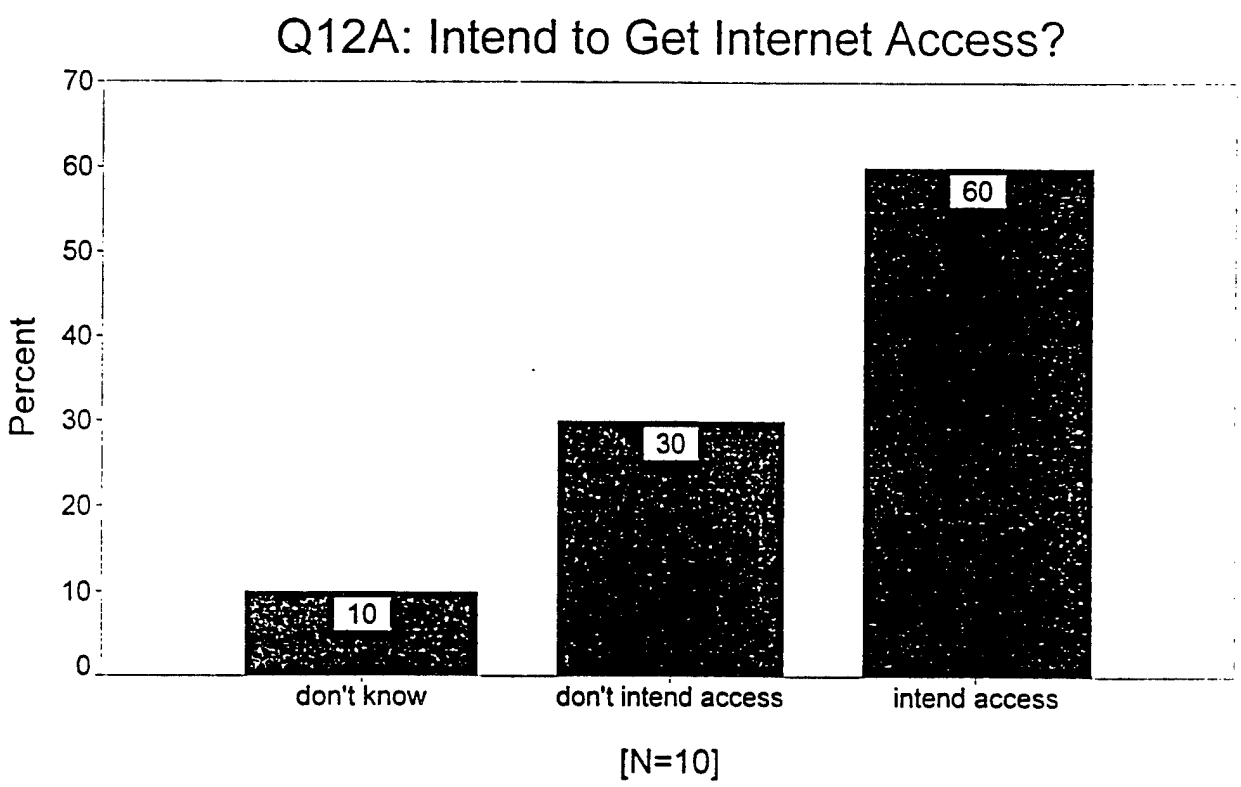
Q11: Importance of Internet Features in T2 [N=79]

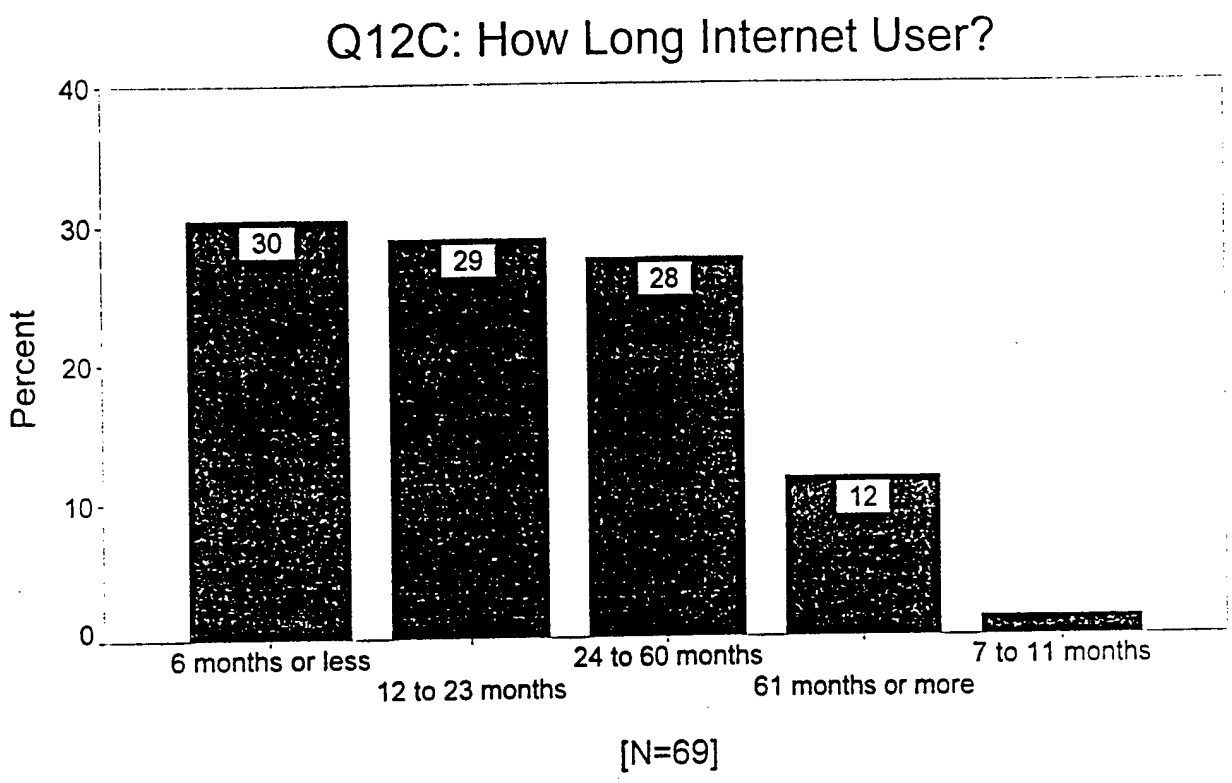


Q12: Internet Access?

[N=81]

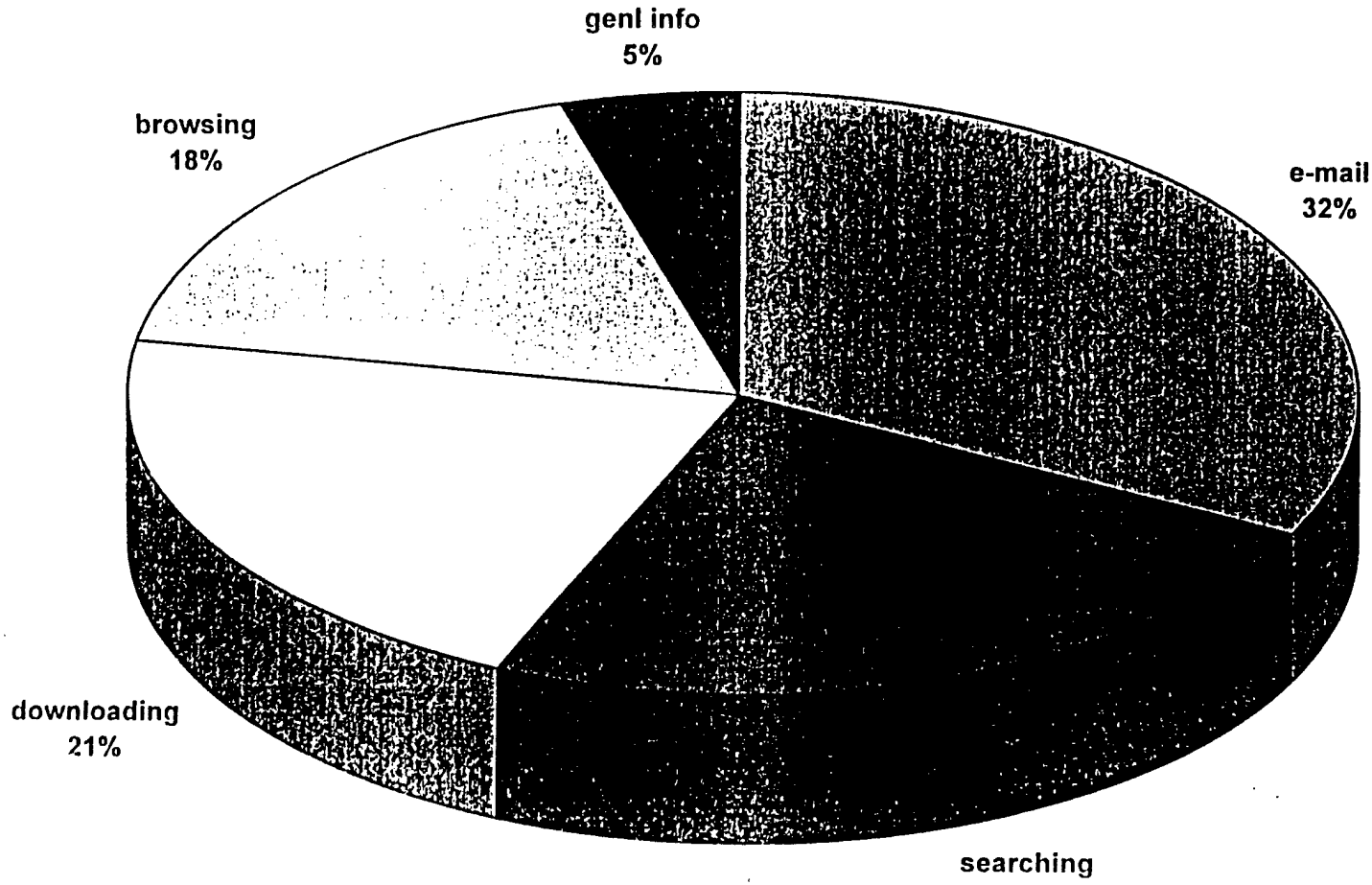



Q12A: Intend to Get Internet Access?
Percent
70
60
50
40
30
20
10
0
10
30
60
don't know
don't intend access
intend access
[N=10]

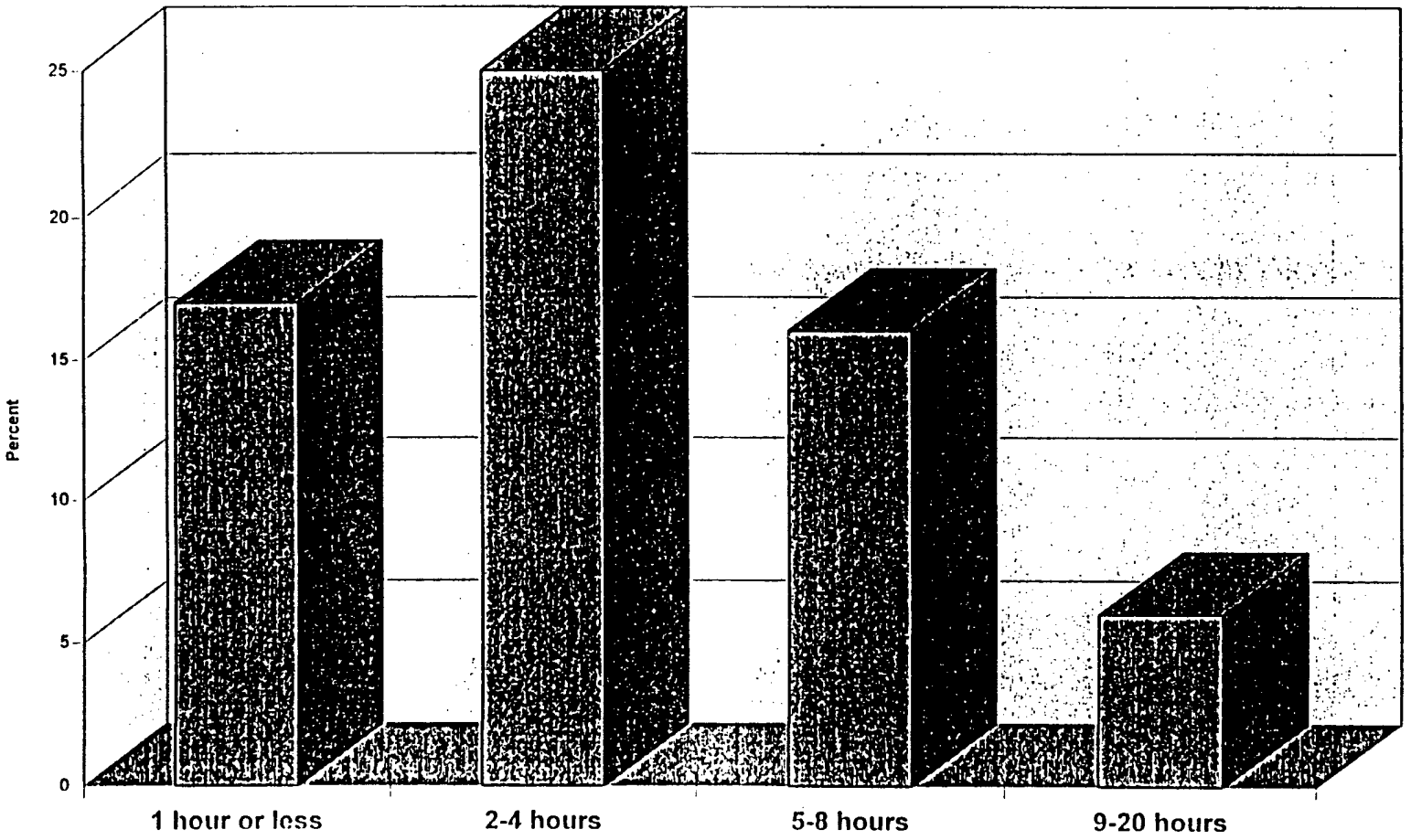

Q12C: How Long Internet User?
Percent
40
30
20
10
0
30
29
28
12
6 months or less
12 to 23 months
24 to 60 months
61 months or more
7 to 11 months

[N=69]

Q12D: Internet Activities Performed [N=67]

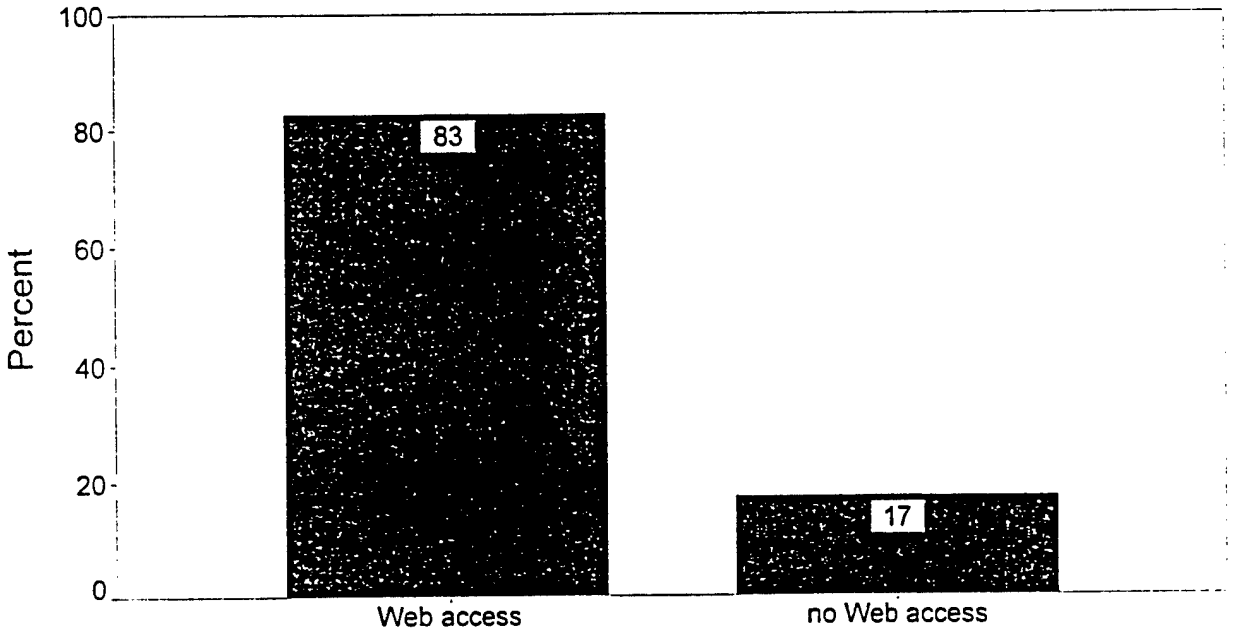


Q12E: Weekly Internet Usage [N=64]



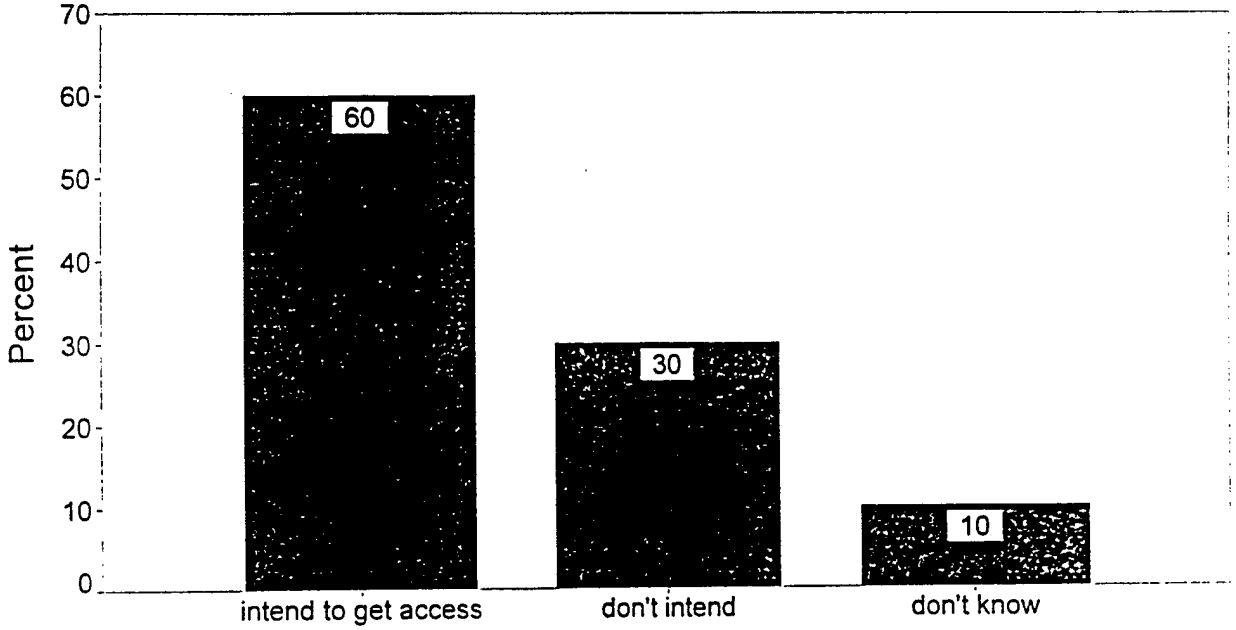
Q13: Access to WWW

[N=81]

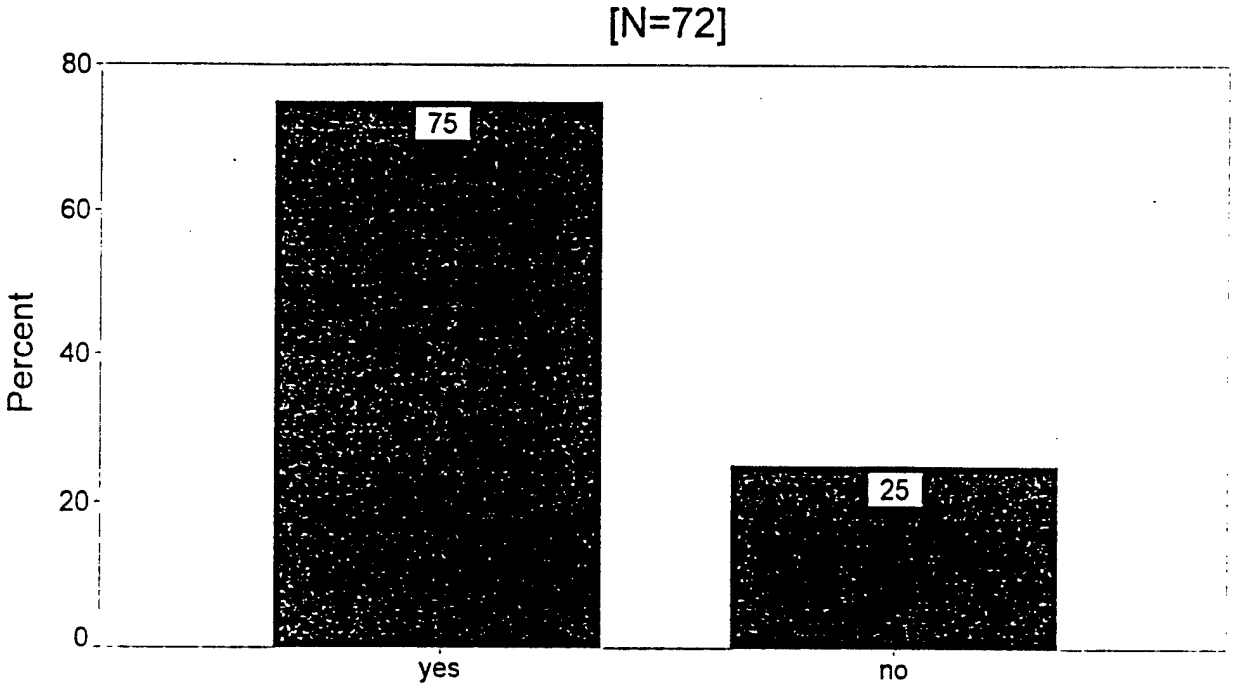


Q13A: Intend to Get WWW Access?

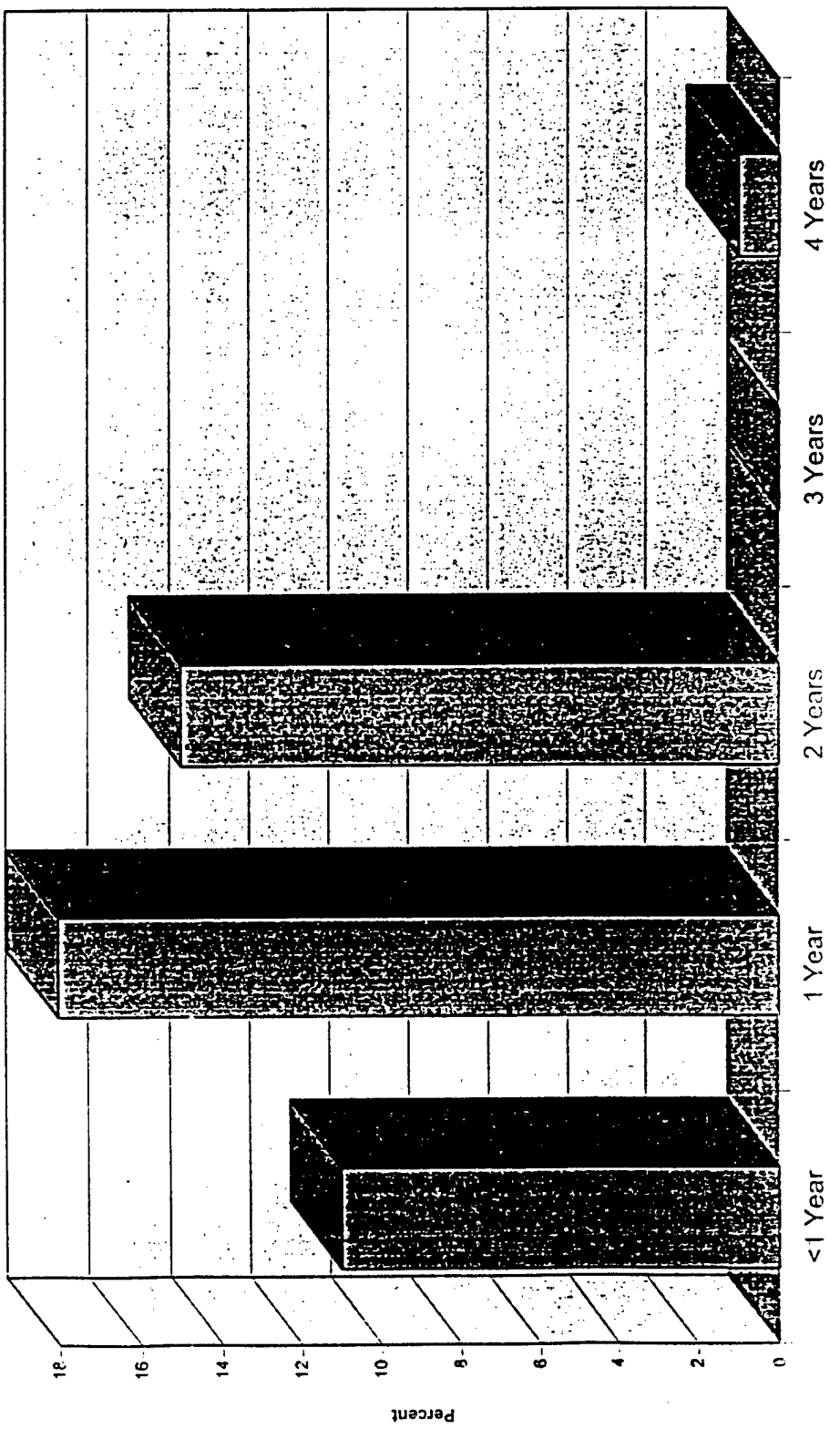
[N=10]



Q14: Organizational Home Page?

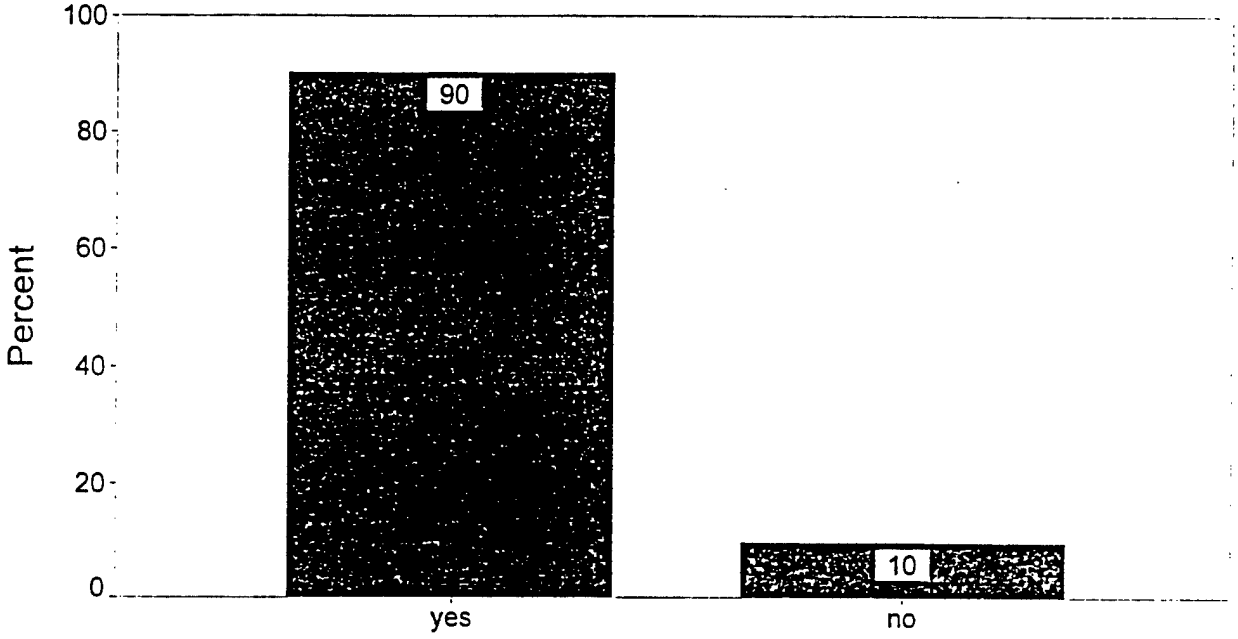


Q14A: Age of Firm's Home Page [N=50]

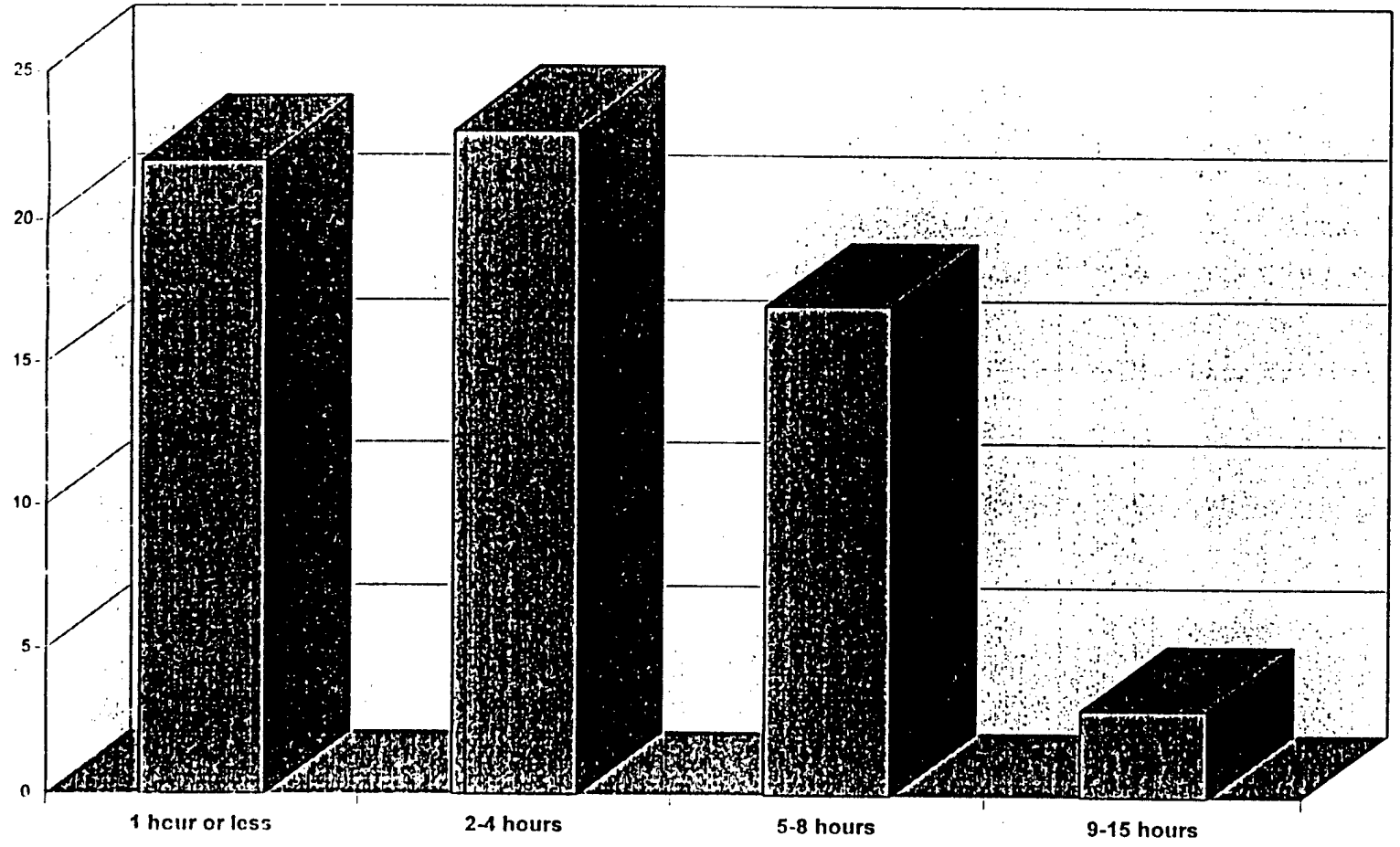


Q15: World Wide Web User?

[N=72]

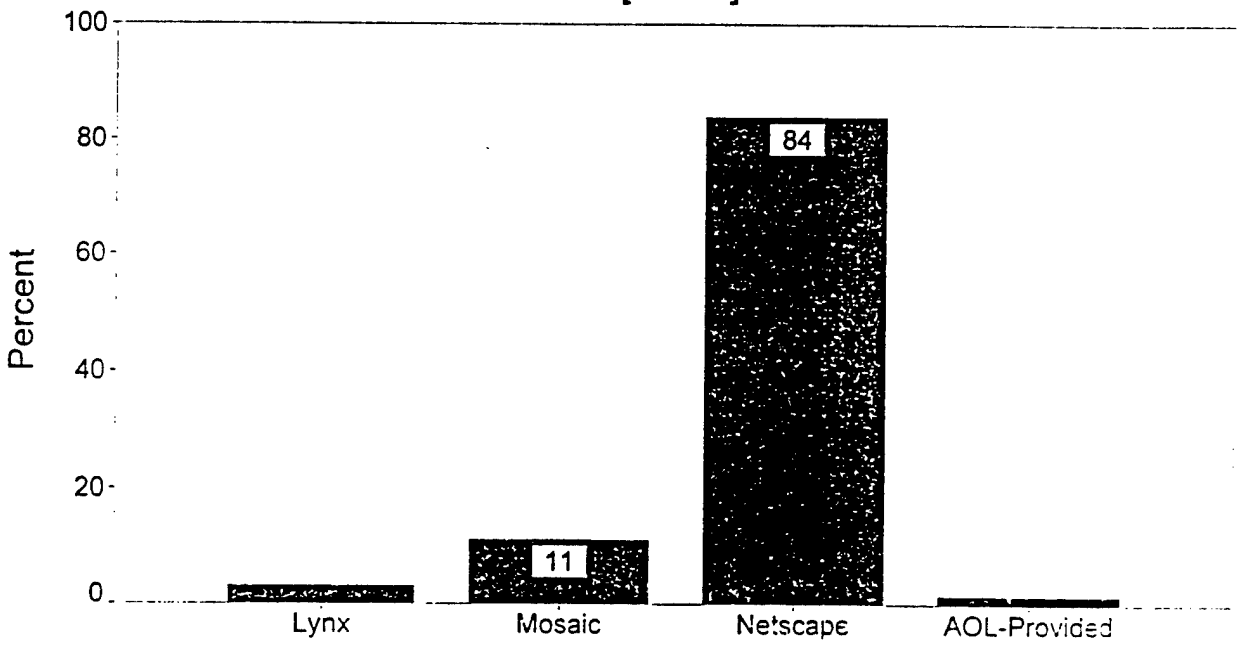


Q15A: WWW Time Weekly [N=65]



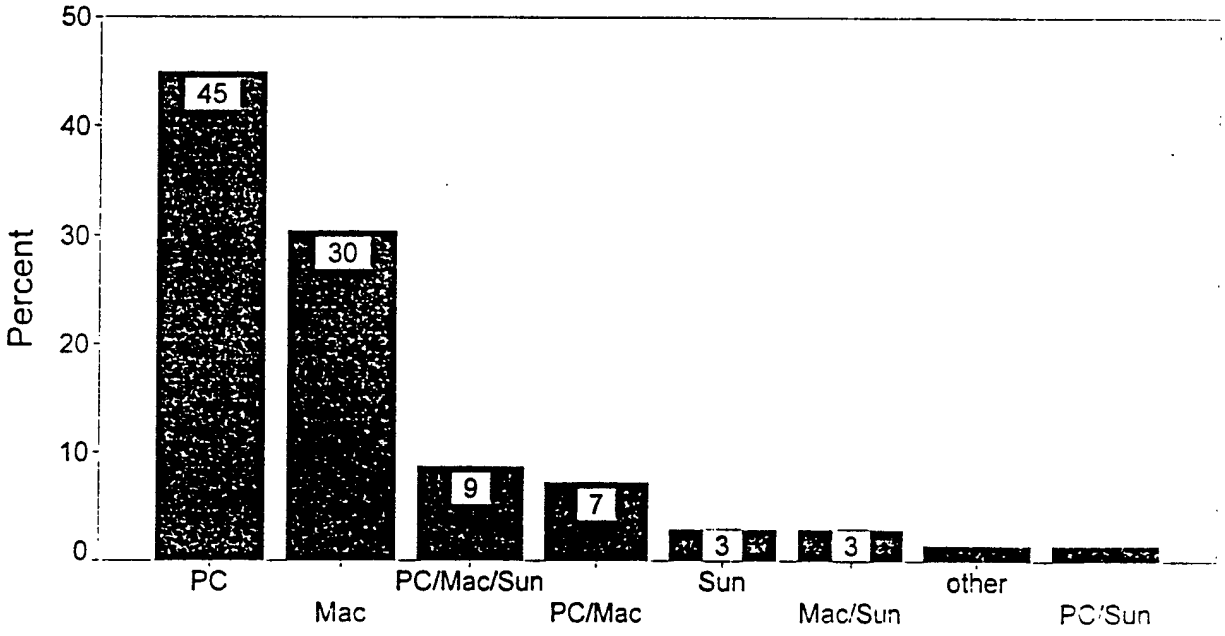
Q15B: Type of Browser Used?

[N=62]



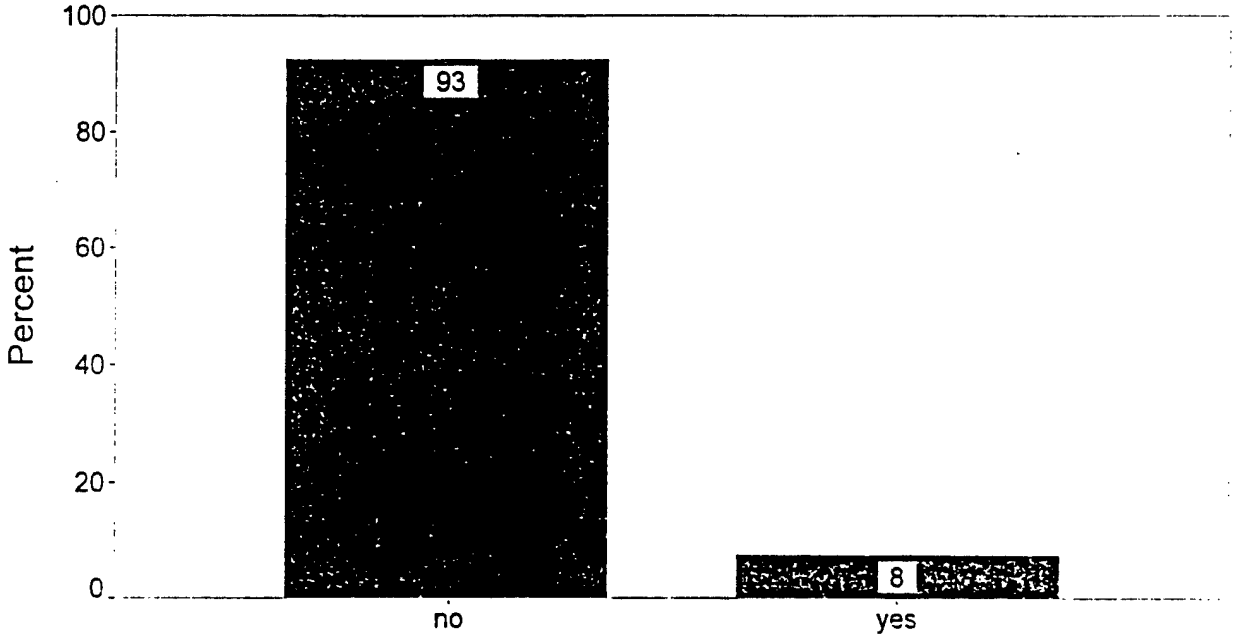
Q15C: Computing Platform

[N=69]



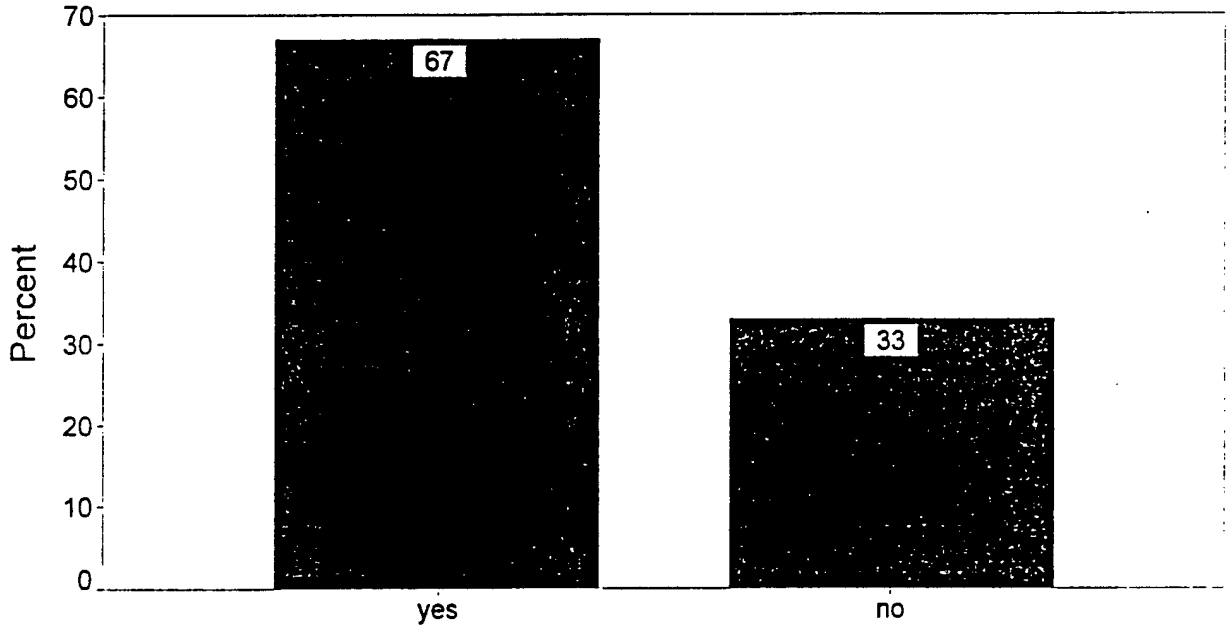
Q16: Listserv User?

[N=80]



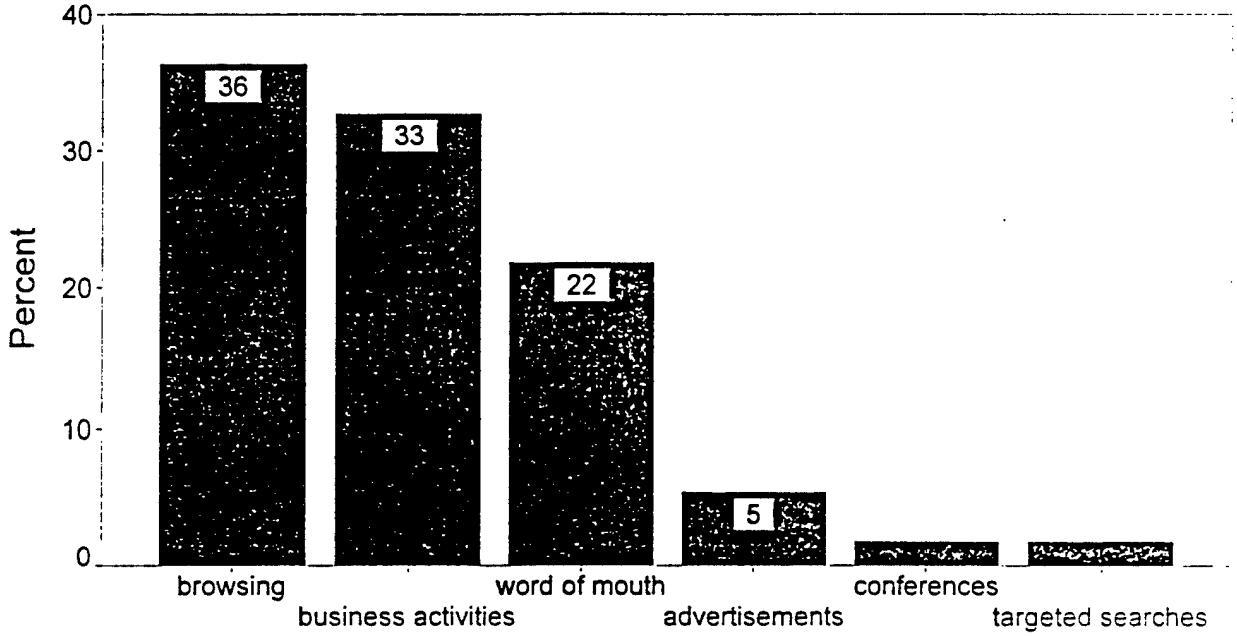
Q18: Use WWW to Visit FedLab HPs?

[N=82]

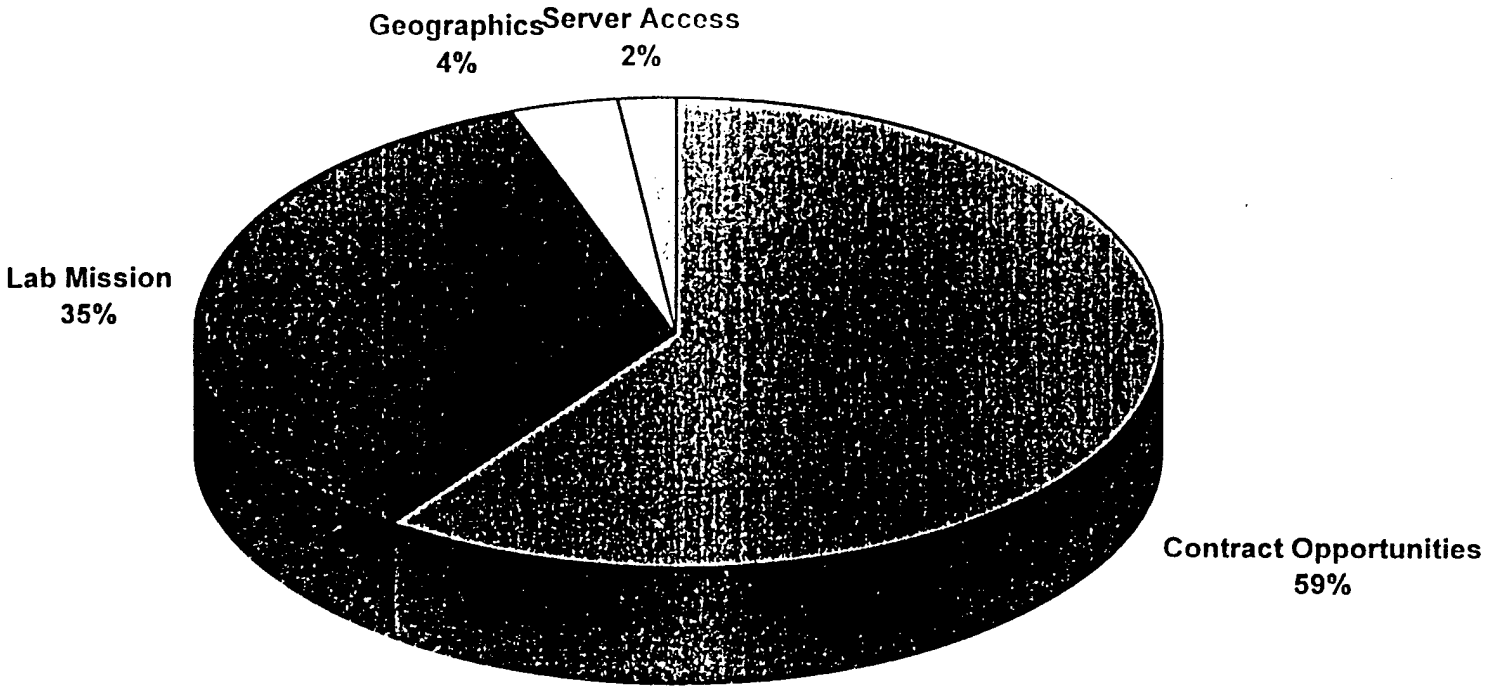


Q18A: Sources of Info Re FedLab HPs

[N=55]

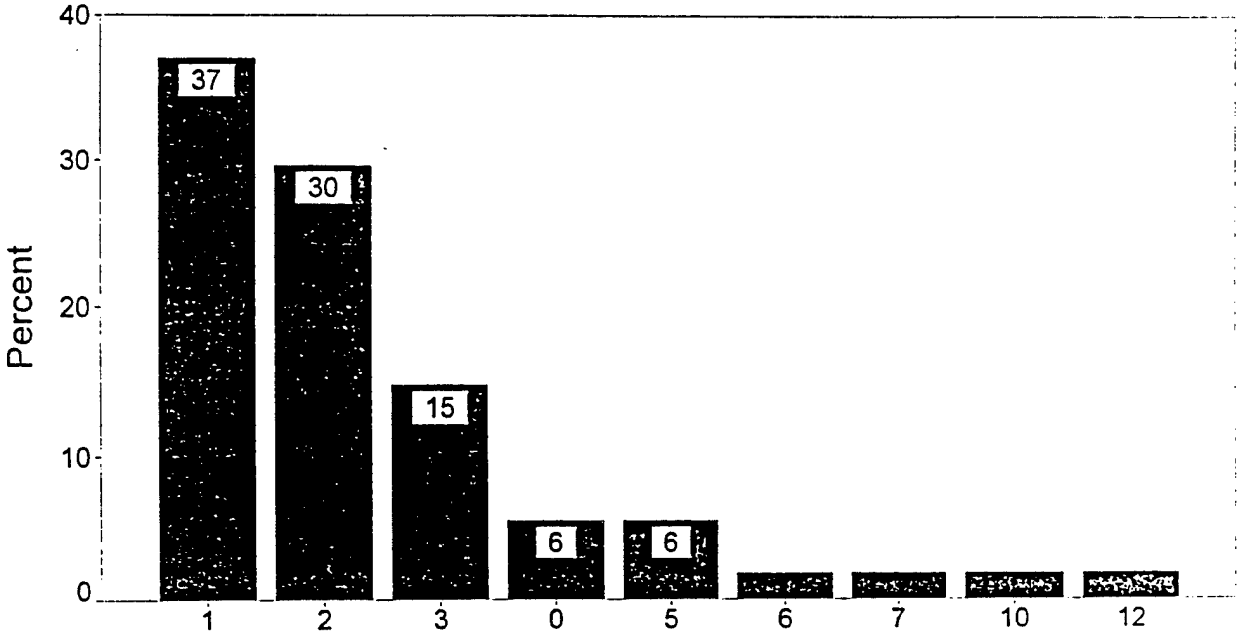


Q18B: Criteria for Visiting Fed Lab HPs [N=55]

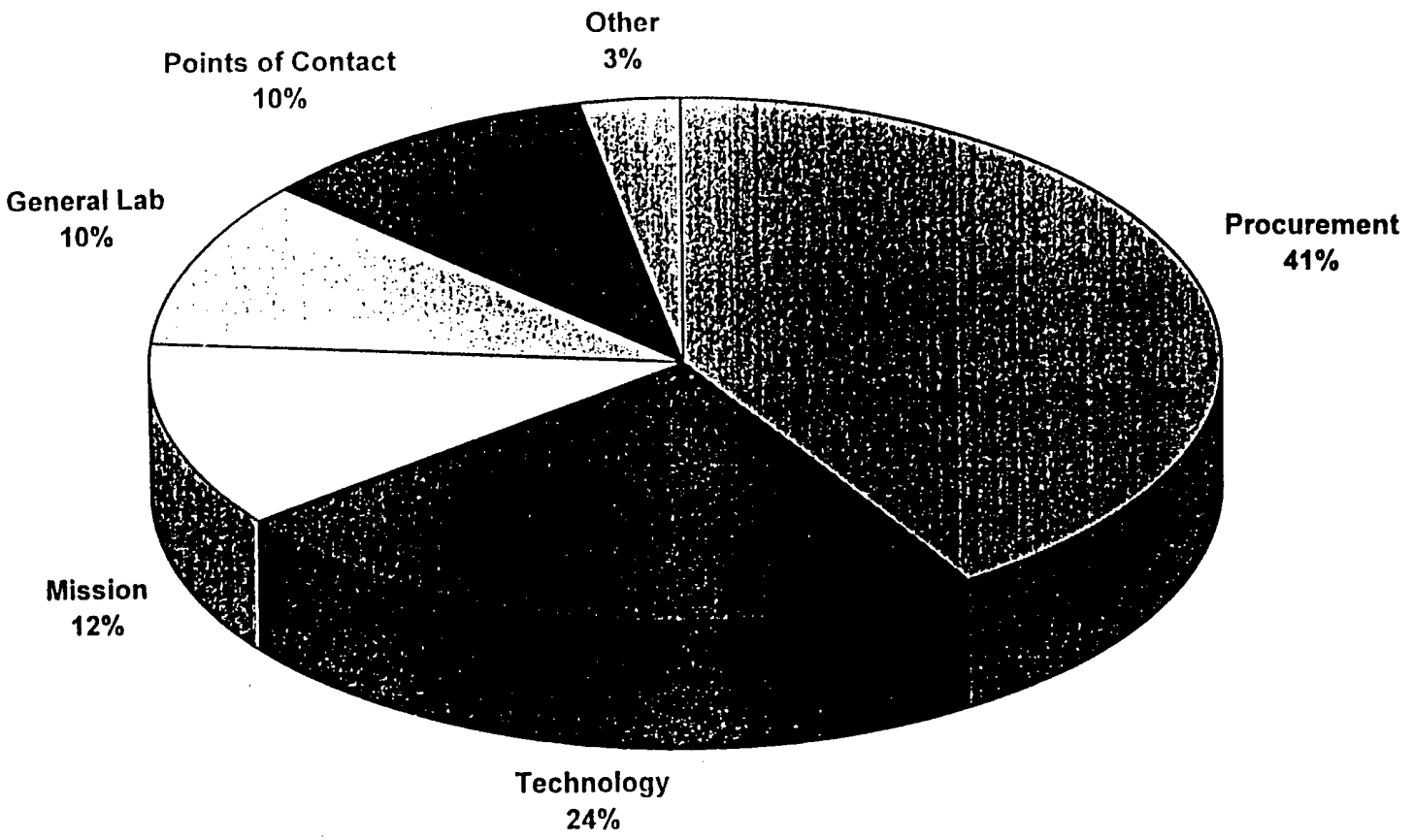


Q18C: FedLab HPs Visited Per Week

[N=54]

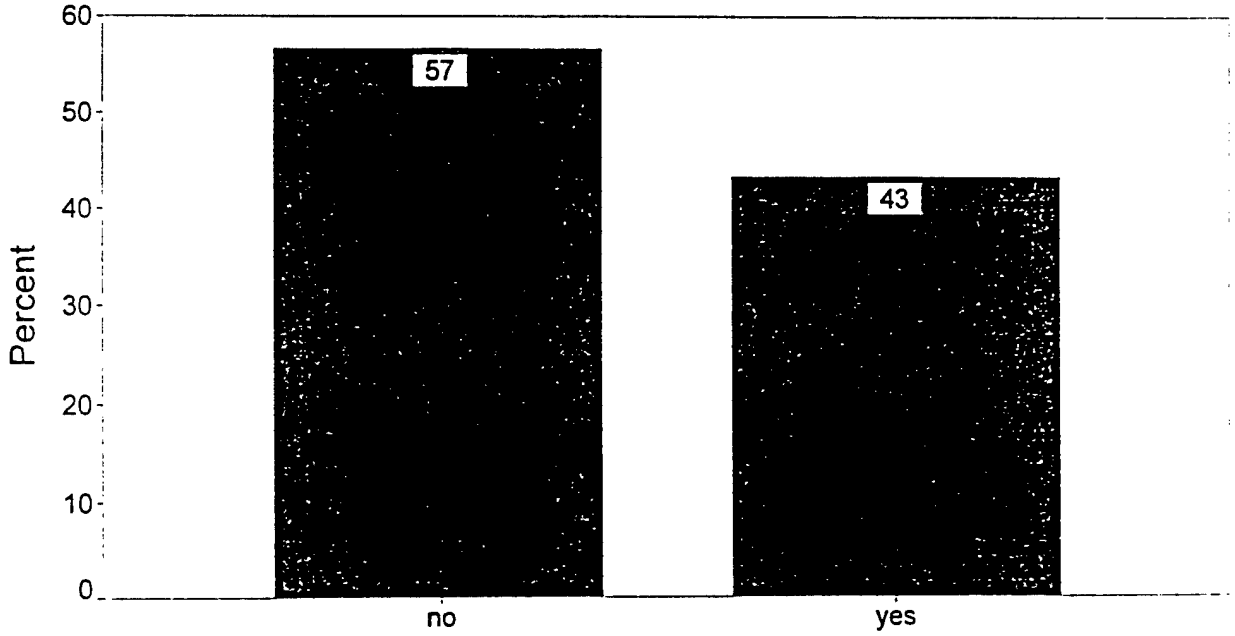


Q18E: Website Sections of Interest [N=39]



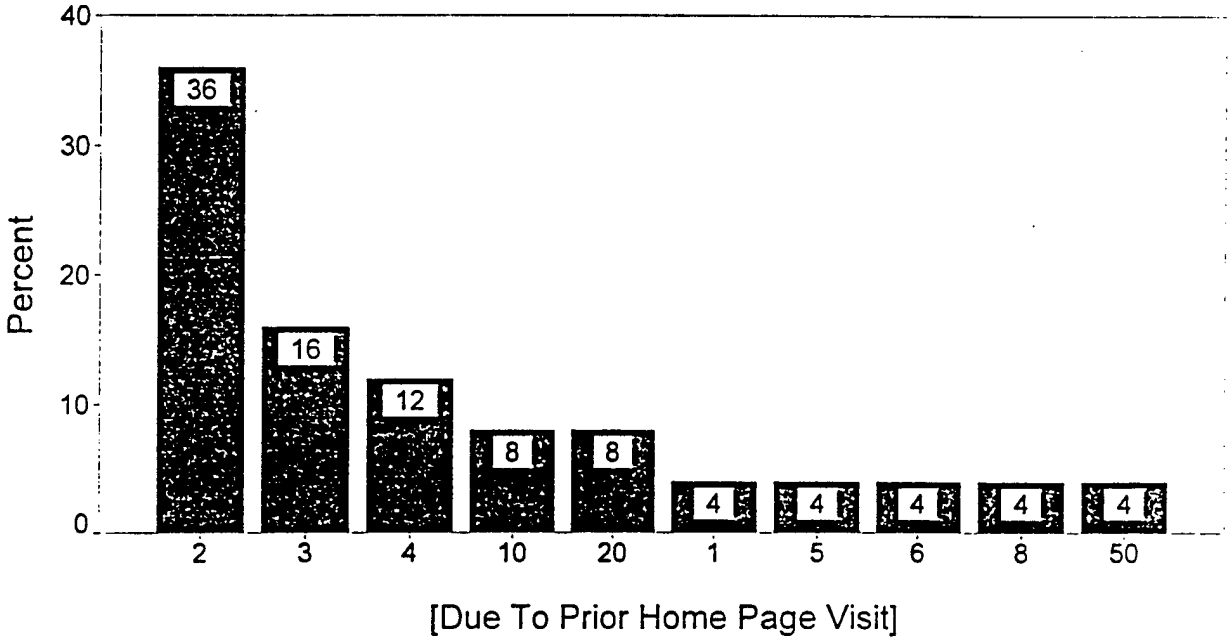
Q19: Contact FedLab Based on HP Content?

[N=60]

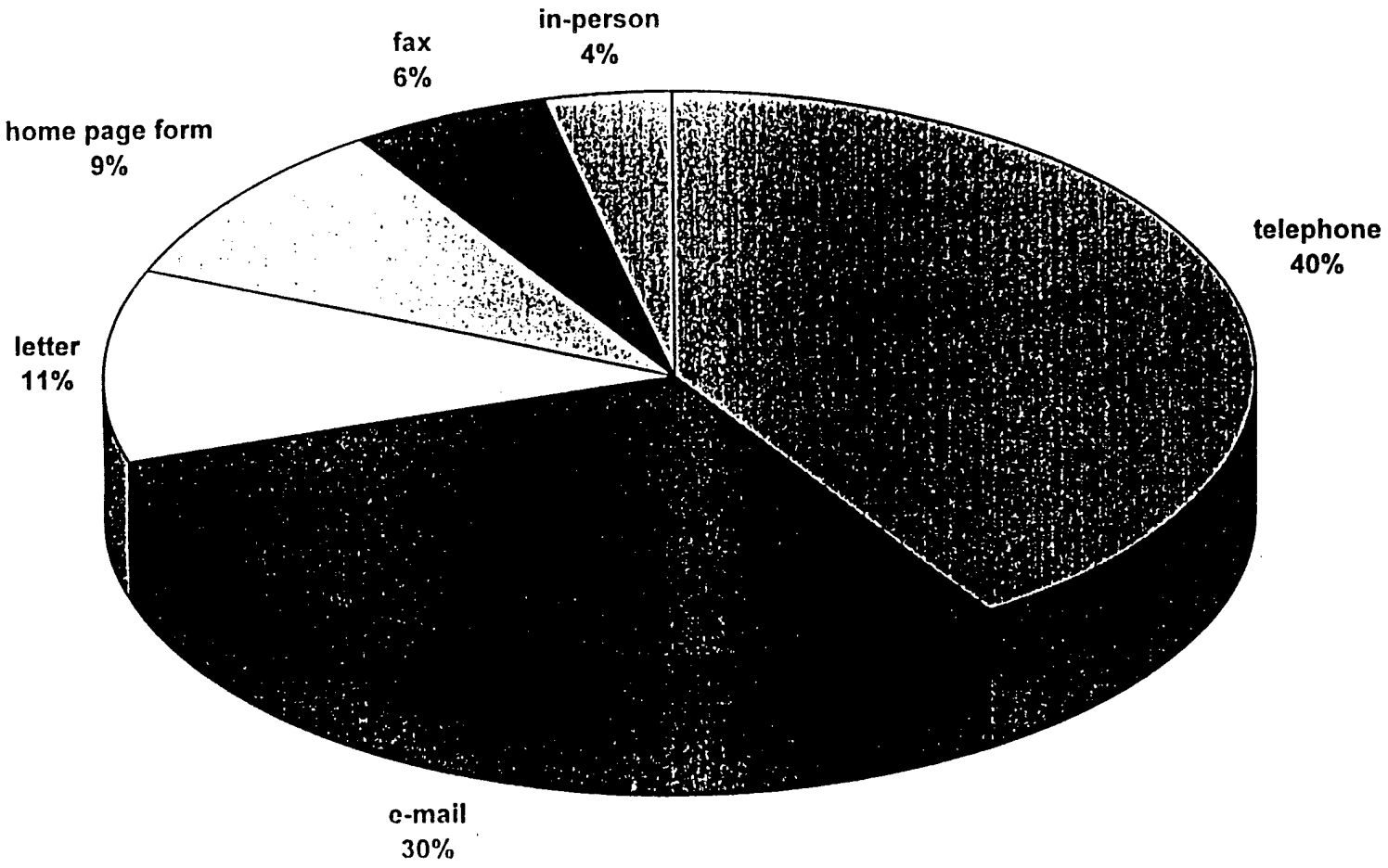


Q19A: # Times Contacted Labs Due to HP

[N=25]

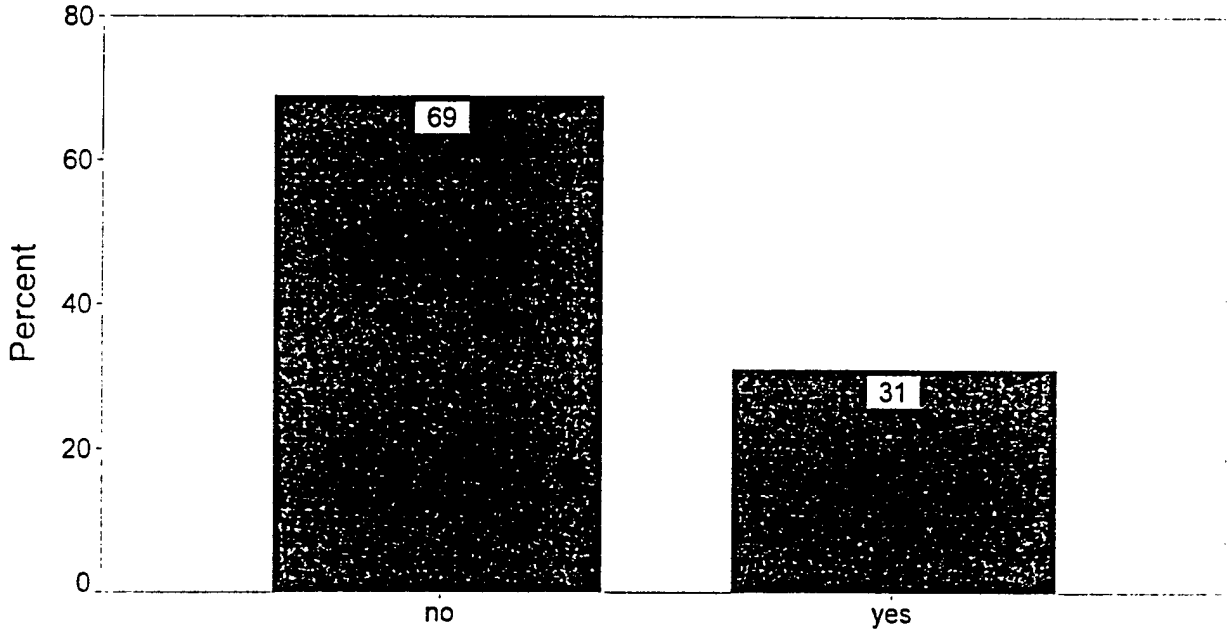


Q19B: Method of Lab Contact [N=26]

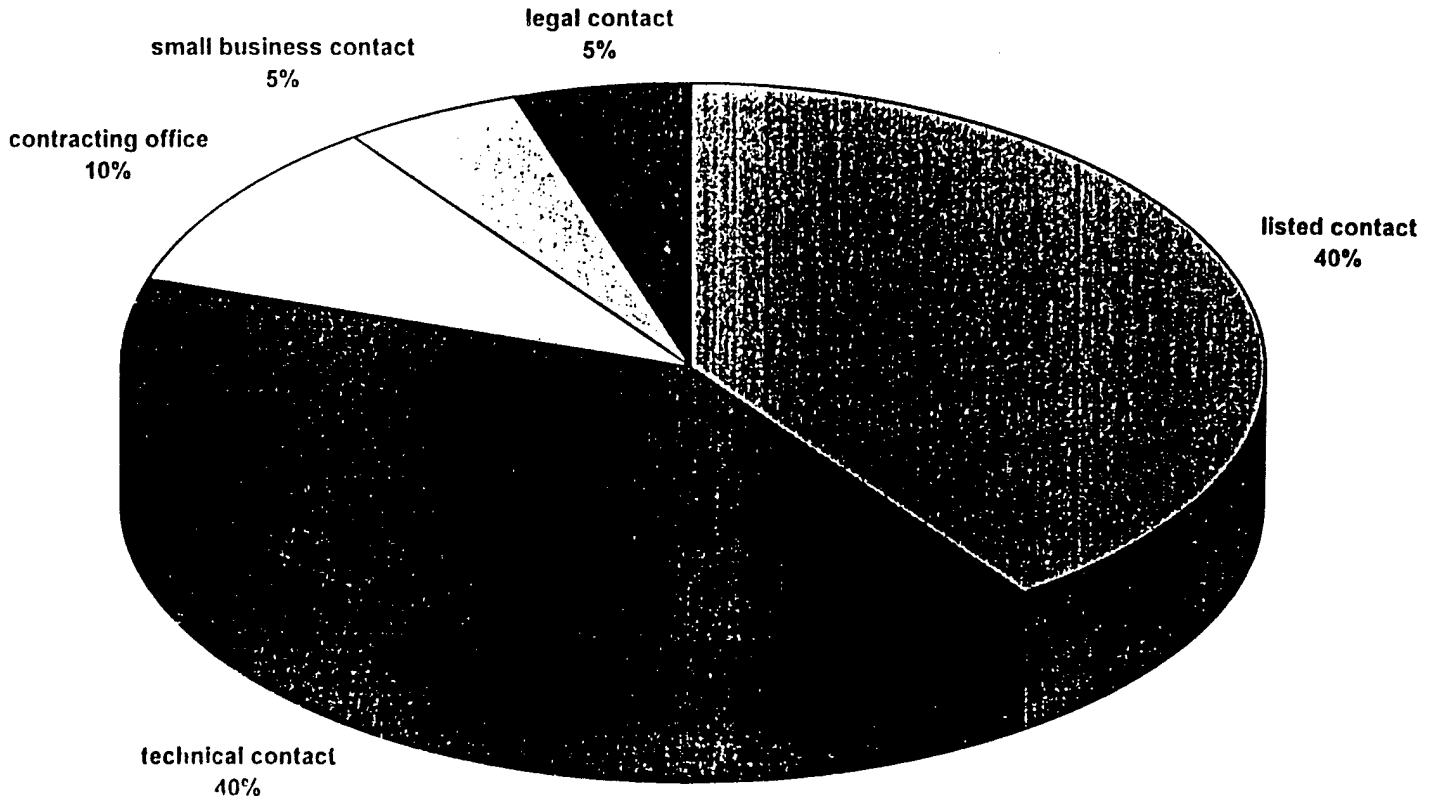


Q19C: Contacted TTO at Fed Lab?

[N=29]

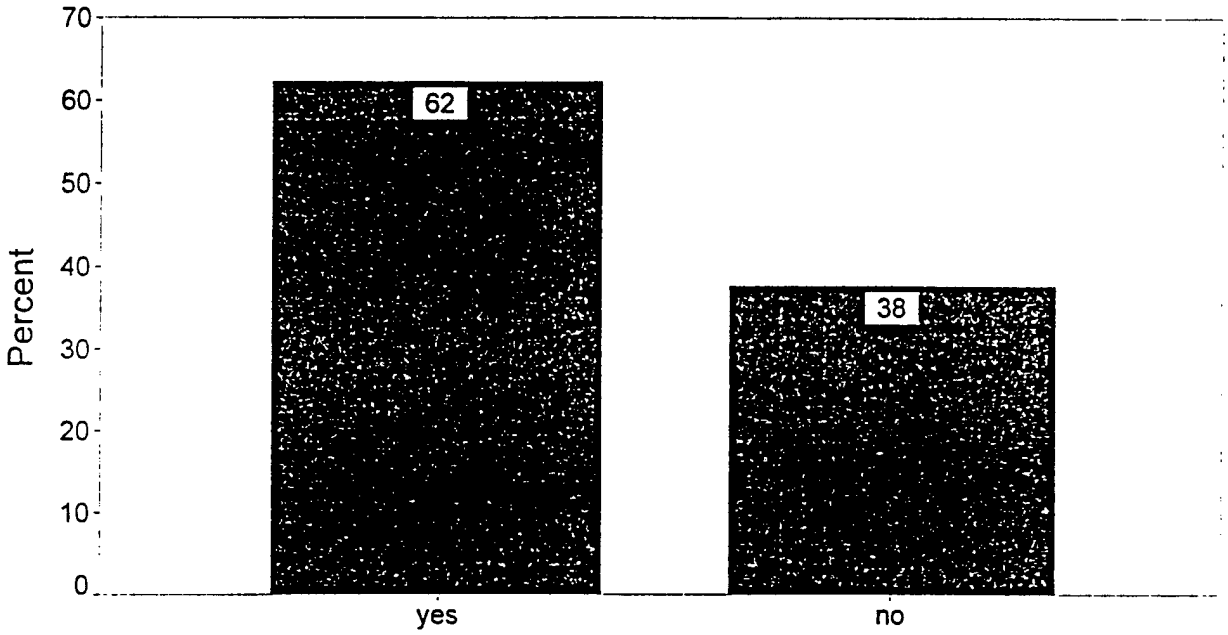


Q19D: Lab Contact [N=17]

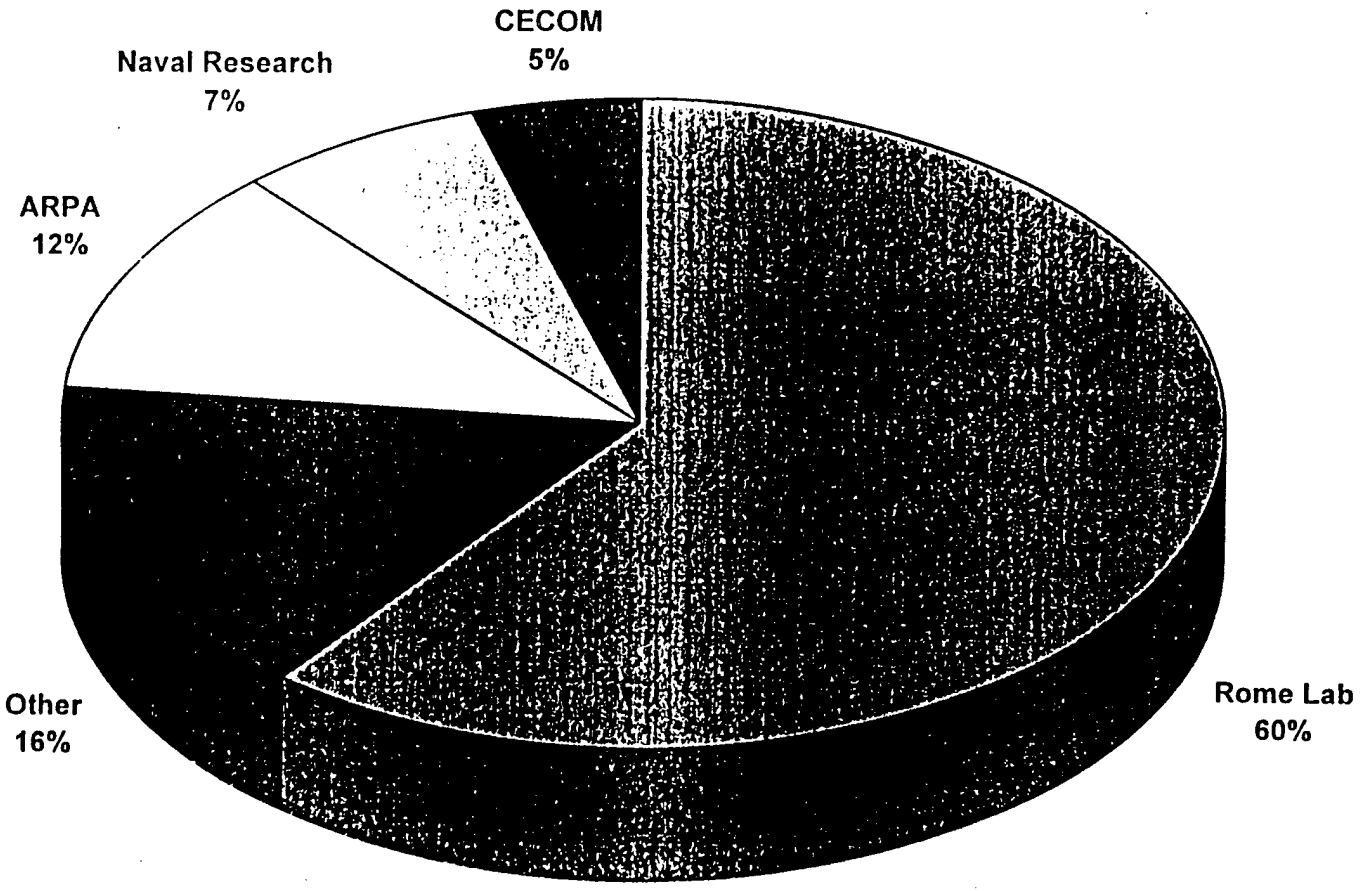


Q20: Have Favorite FedLab HP?

[N=61]



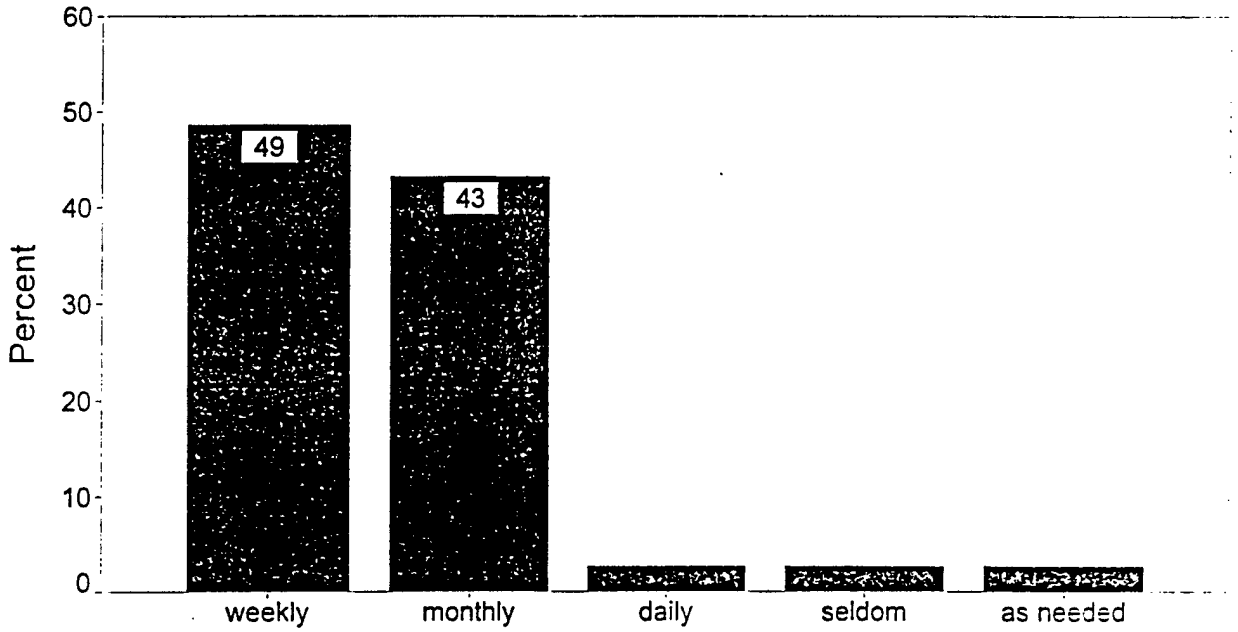
Q20A: Favorite Fed Lab Websites [N=38]



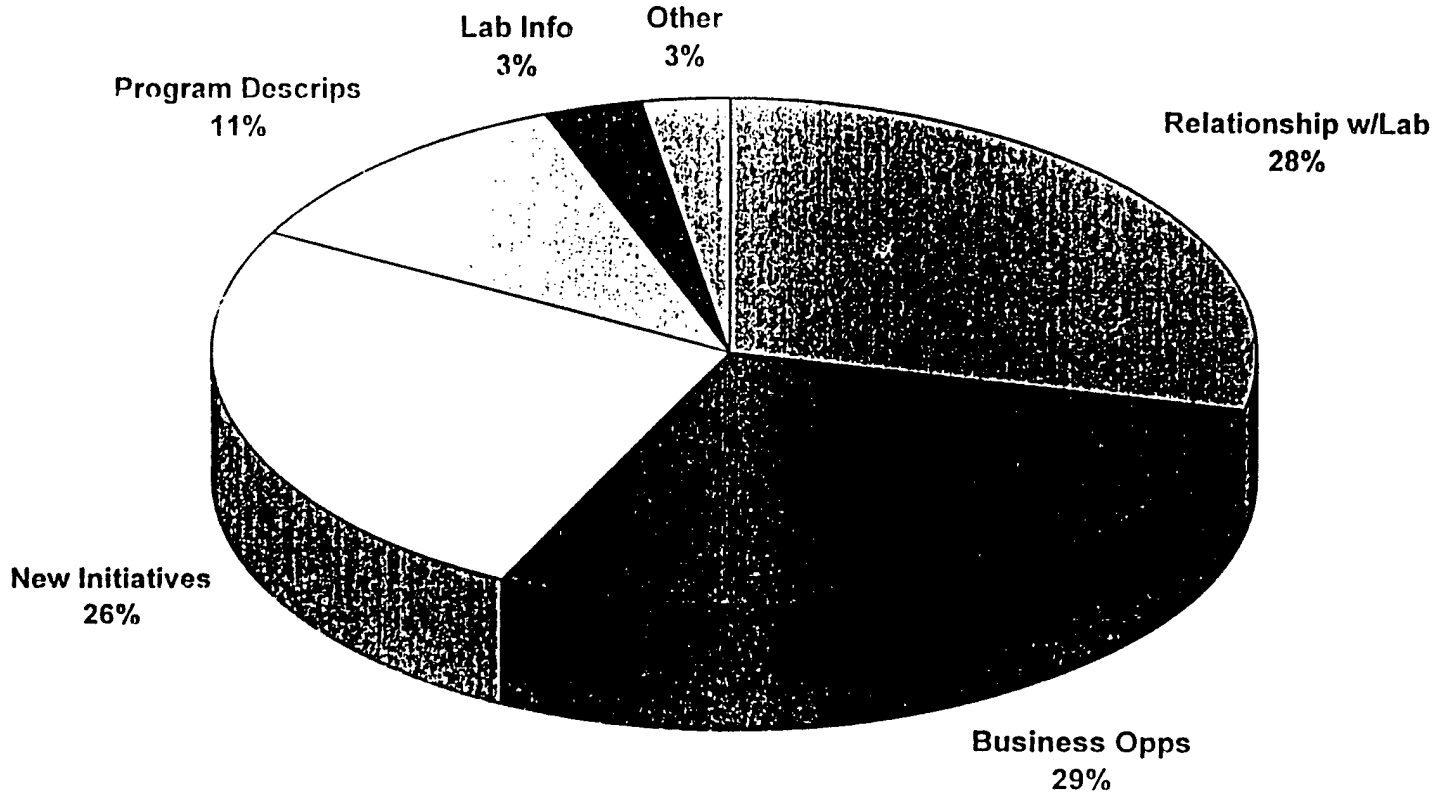
"other" labs had 1 vote each

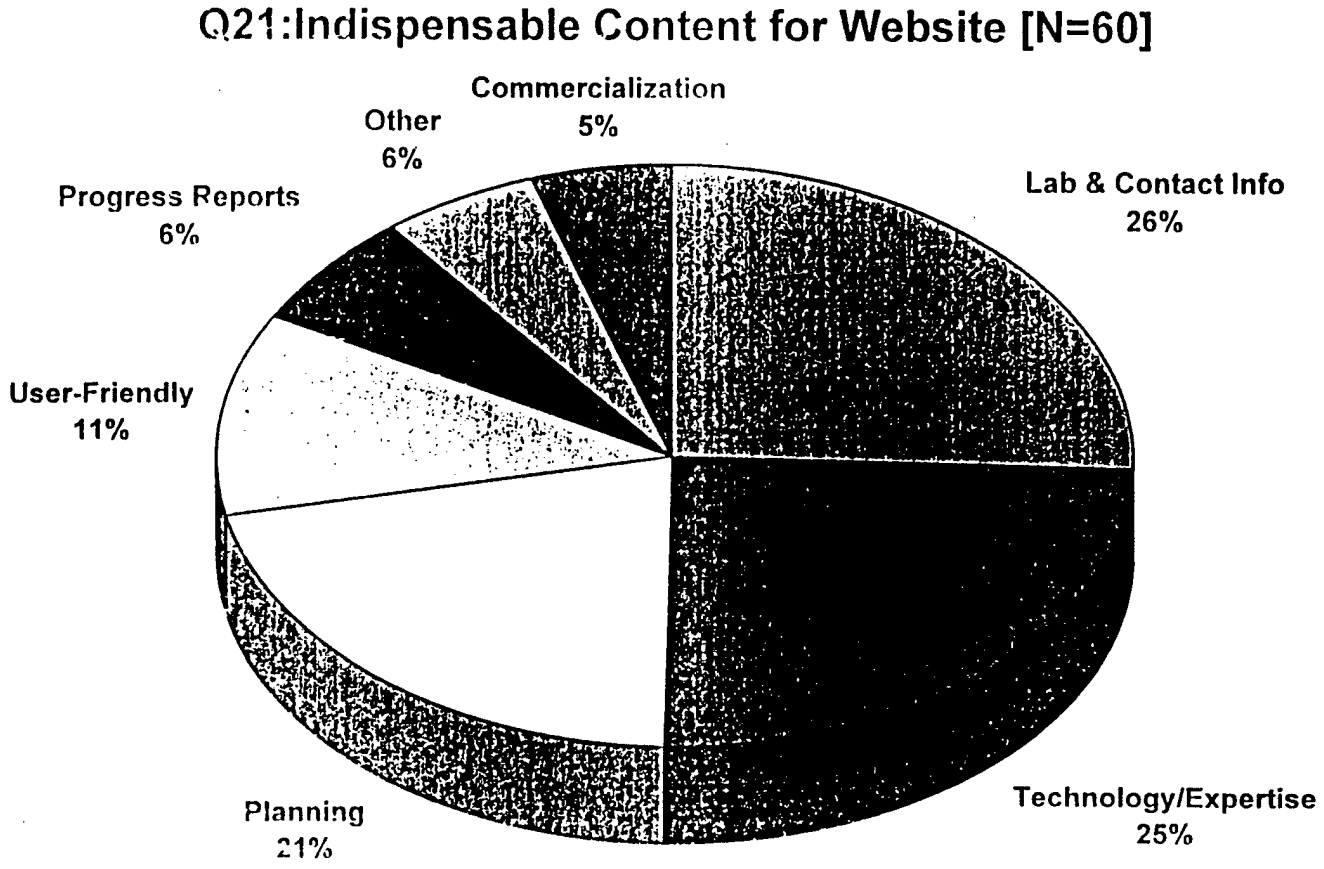
Q20B: How Often Visit Favorite FedLab HP

[N=37]

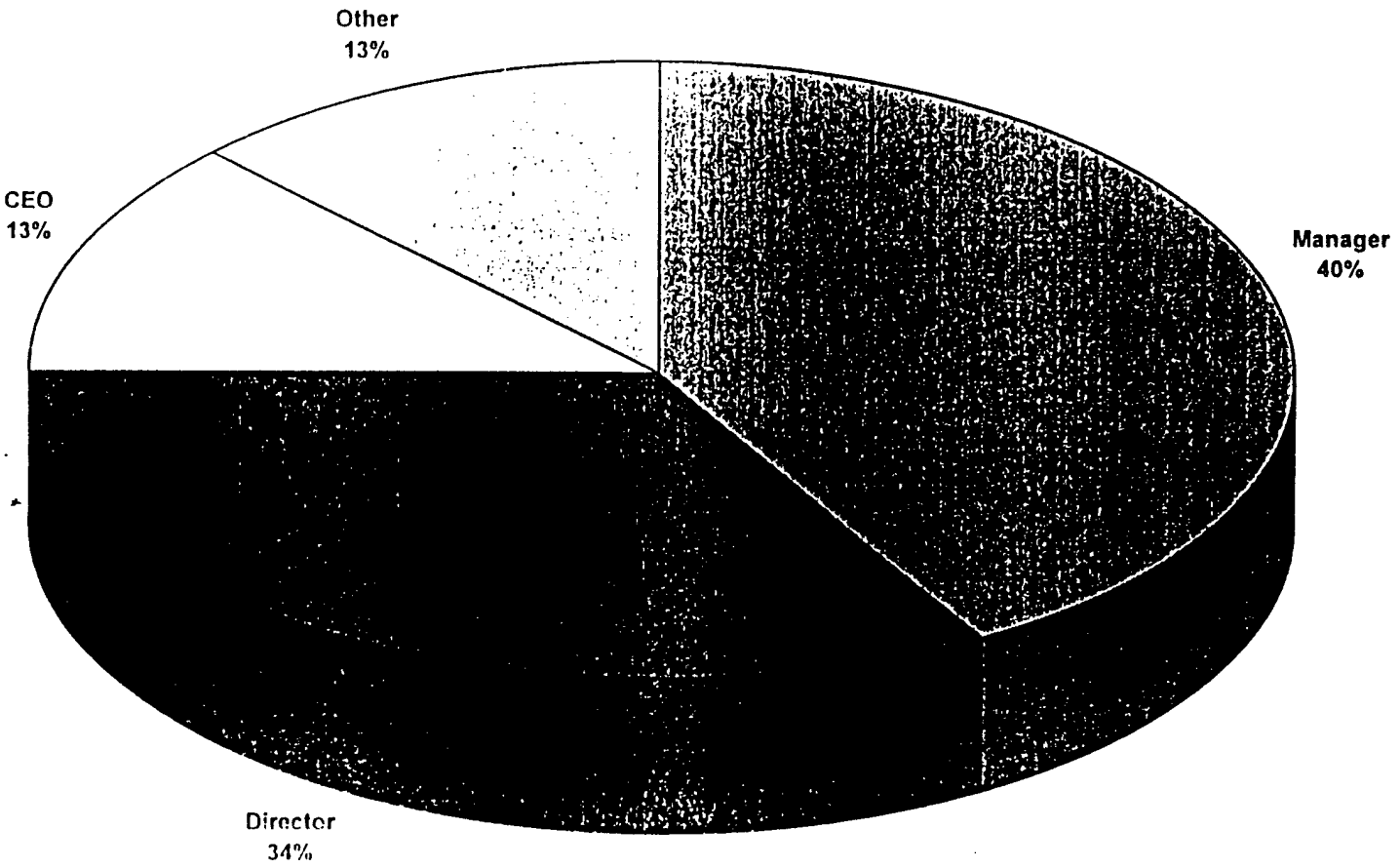


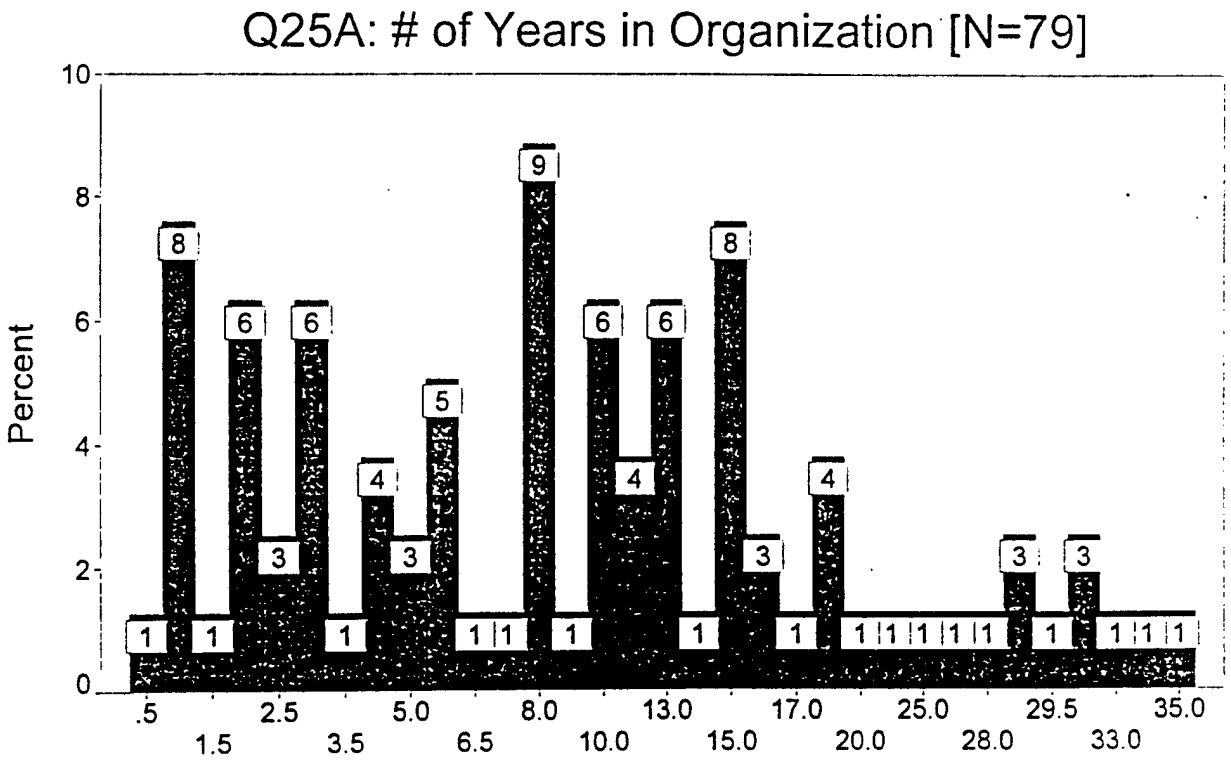
Q20C: Reasons for Returning to Website [N=35]

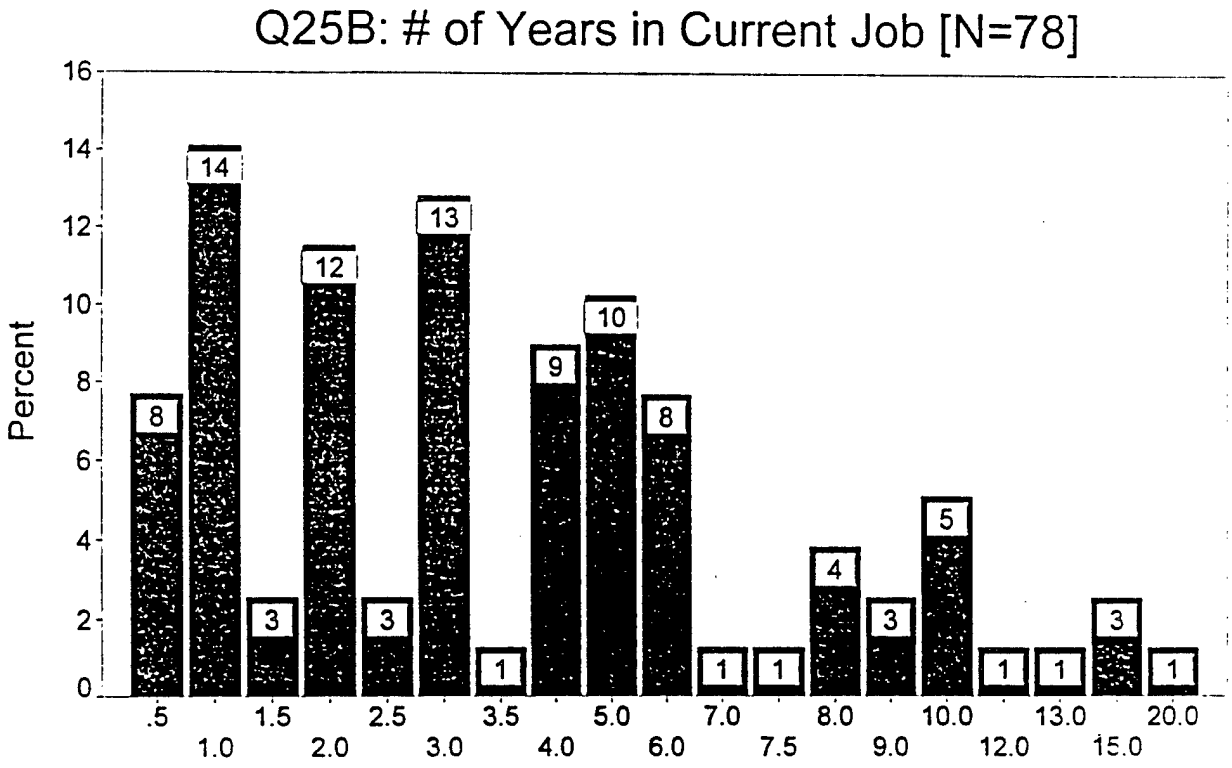



Q21:Indispensable Content for Website [N=60]
Commercialization
5%
Other
6%
Progress Reports
6%
Lab & Contact Info
26%
User-Friendly
11%
Planning
21%
Technology/Expertise
25%

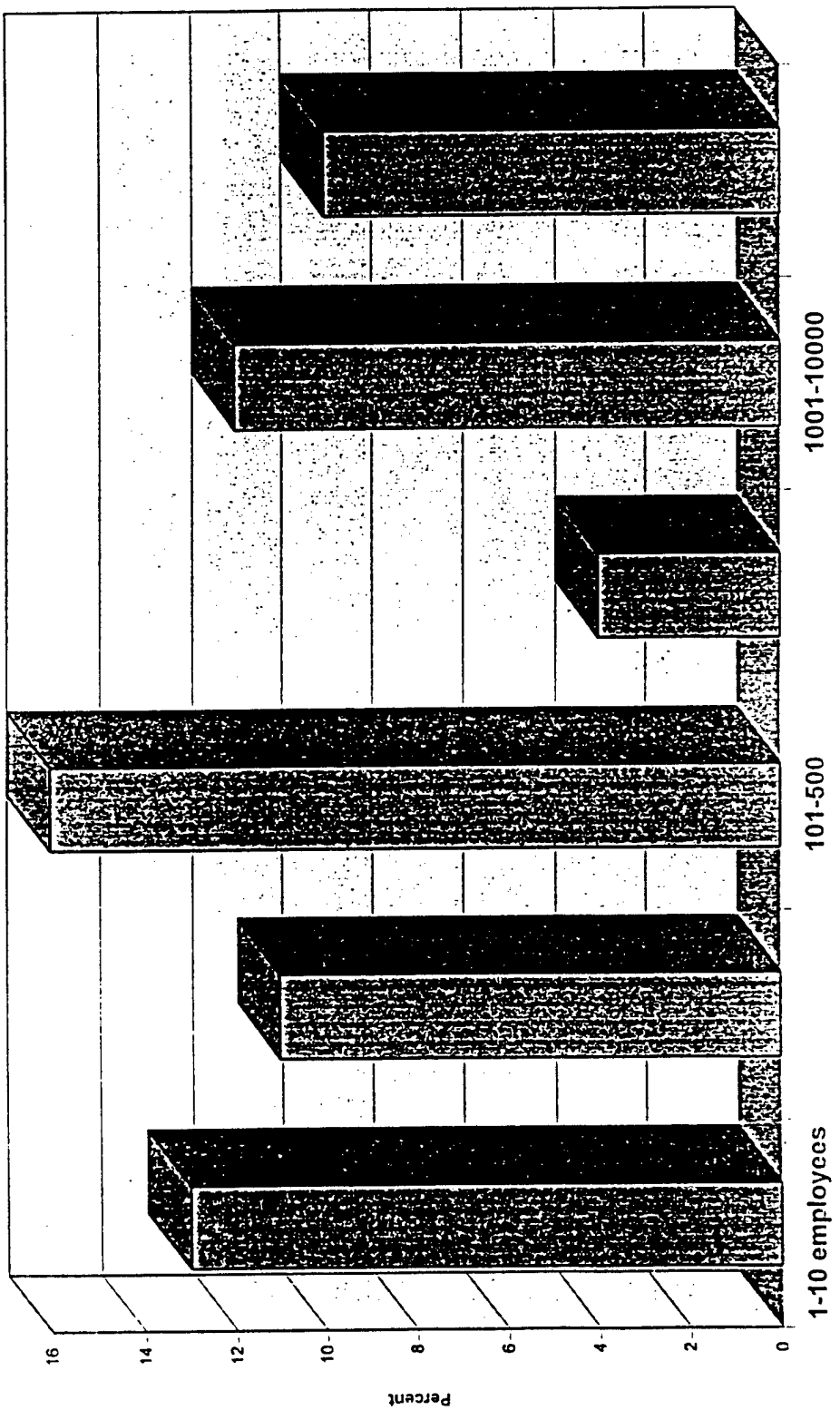
Q23: Job Title of Respondent [N=84]




Q25A: # of Years in Organization [N=79]
Percent
10
8
6
4
2
0
.5
1.5
2.5
3.5
5.0
6.5
8.0
10.0
13.0
15.0
17.0
20.0
25.0
28.0
29.5
33.0
35.0

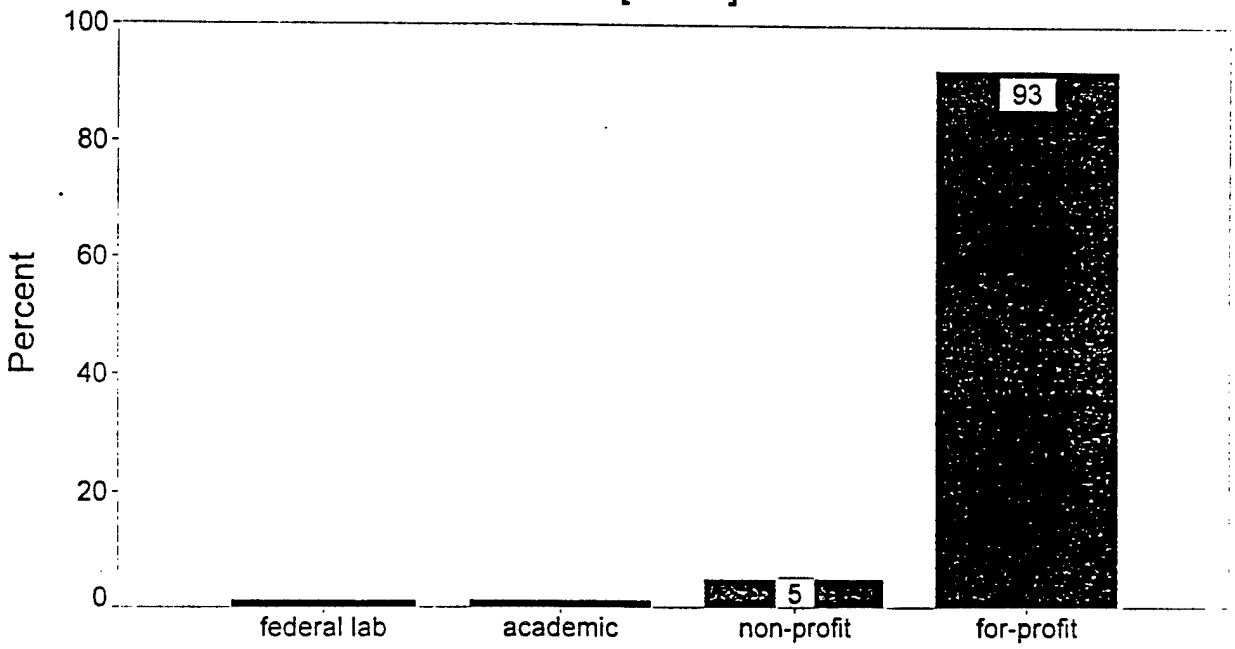

Q25B: # of Years in Current Job [N=78]
Percent
16
14
12
10
8
6
4
2
0
8
14
3
12
3
13
1
9
10
8
1
1
4
3
5
1
1
3
1
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
5.0
6.0
7.0
7.5
8.0
9.0
10.0
12.0
13.0
15.0
20.0

Q26: Number of Employees [N=77]



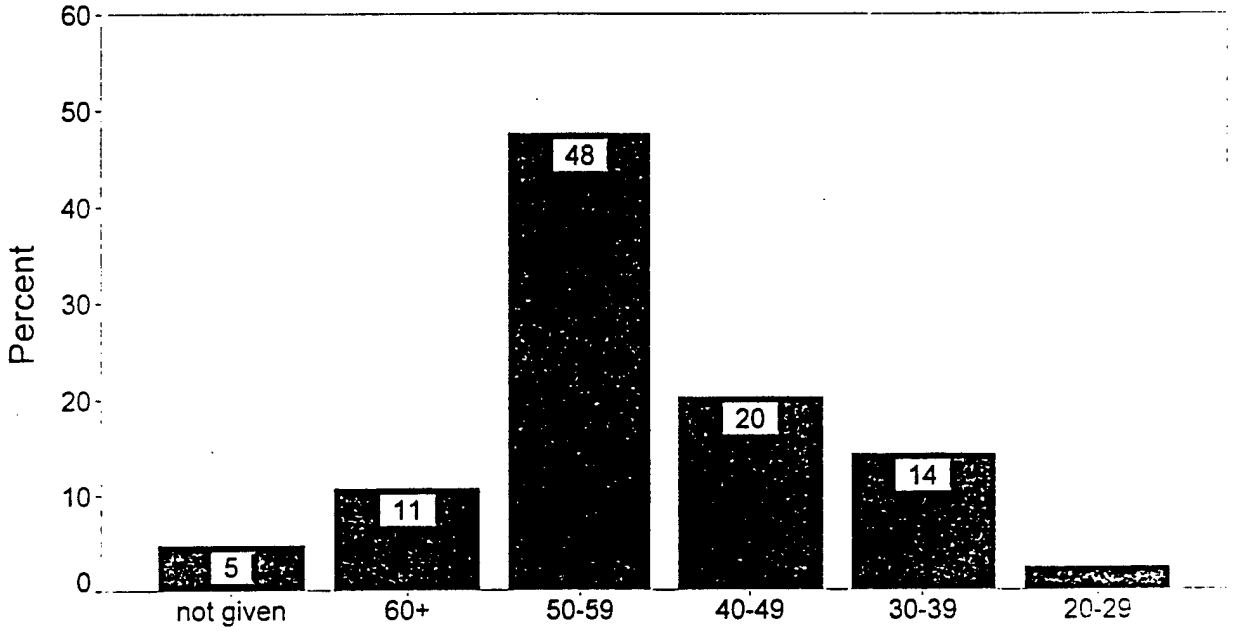
Q28: Organization Type

[N=81]



Q29: Age of Respondent

[N=84]



Appendix C:
Directorate Description

ROME LABORATORY COMMAND, CONTROL, AND COMMUNICATIONS DIRECTORATE

http://www.rl.af.mil:8001/Technology/FactSheet/Fact-C3.html

The Command, Control and Communications Directorate of the Air Force Materiel Command's Rome Laboratory, Rome, New York, conducts research and development programs in computer and software technologies and communications techniques as applied to the command, control and communications mission. Major areas of investigation for the Directorate's scientists and engineers include: software engineering, computer security, artificial intelligence; decision aids; distributed data processing; ground, air and space radio communications, optical communications and network technology; communications signal processing and processors.

For further information visit the Command, Control and Communications Directorate's home page.

TABLE OF CONTENTS

- Special Facilities
  1. Command and Control Technology Center
  2. Distributed Systems Evaluation Environment
  3. Information and Computer Security Testbed
  4. Computer Science and Technology Center
  5. Communications Experimental Facility
  6. Network Design Facility
  7. NYNET
  8. Advanced Multi-Media Information Distribution (AMIDS) Center
  9. Multi-Level Security (MLS) Test Facility
  10. Advanced Displays and Intelligent Interfaces

MAJOR TECHNOLOGY AND PROGRAM AREAS

Major areas of investigation for the Directorate's scientists and engineers include: software engineering, computer security, artificial intelligence; decision aids; distributed data processing; ground, air and space radio communications, optical communications and network technology; communications signal processing and processors. Directorate efforts address traditional transmission media such as radio and wire cables, as well as emerging technologies in lightwave communications links and photonic processors. Technology demonstrations of the research and development products from these areas are conducted within the Air Force and Department of Defense.

Directorate technology and demonstration programs include

****Force Level Execution (FLEX).** This program will develop and demonstrate an automated execution capability to support the Combat Operations Division of the Air Operations Center (AOC) under the Theater Battle Management (TBM) Initiative.

****Advanced Display and Interface Technology (ADIT) Program.** This program will evaluate and develop advanced technologies for portraying and manipulating large quantities of data for application in future C2 systems.

****Systems Engineering.** This program is developing the CATALYST System Engineering capability which allows the integration and use of CASE, CAD/CAM, etc. in a cohesive manner.

The product will provide automated system engineering support over the life cycle.

****Certification of Reusable Software Components.** A development for a certification methodology, framework, and tools to enable software developers and reuse/reengineering activities to determine a "level of confidence" in candidate software components identified as having reuse potential whether these components exist in a library or have been applied in like systems. Levels of certification will be based on user needs analysis and the desired/required confidence level sought.

****Software Engineering for Parallel Computers.** A program to develop software

engineering technology to cope with complex systems consisting of a mix of sequential and highly parallel computing equipment. The focus is on developing software engineering tools and methods to realize the performance gains offered by parallel computers.

**Requirements Engineering. The Rome Laboratory program in this area is concentrated on producing a Requirements Engineering Environment to enable end-item users to become involved in the requirements process, to provide techniques for automated code production, develop reusable specifications, and to integrate requirements engineering technology more fully with the life cycle process. The Environment attempts to overcome requirements oriented problems by keeping the user involved in the process and by providing the user with an early, and first hand, view of what the final product should look and feel like.

**Software Quality Technology Transfer Consortium. The Rome Laboratory Software Quality Technology Transfer Consortium is a joint-applied research and development initiative between Rome Laboratory and several corporations from the U.S. defense industry. The purpose of this initiative is two-fold: to assist the industry in the application of the science of software measurement and to provide testbeds for evaluating this science. The Consortium concept is a means to improve the capability of participating companies to produce quality software and accelerate knowledge about the models, methods and procedures of how to most efficiently produce quality software. This is being accomplished through the cooperative application of software quality methods, tools and procedures produced by Rome Laboratory and the exchange of experiences and data associated with these applications between participating organizations.

**Knowledge Based Planning. This technology is concerned with development of technology that will facilitate rapid construction and repair of resource allocation plans. Current emphasis is on the development of the next generation of AI planning and scheduling generic tools to assist on large scale planning, resource allocation and scheduling problems typified by force deployment deliberate and crisis action planning. The resulting new capabilities will demonstrate an integrated suite of planning tools ready for application.

**Knowledge Based Software Assistant. This program is developing an AI based approach to software engineering that provides orders of magnitude improvements in software productivity, major decreases in software maintenance costs, and magnitudes of increase in software reusability. This program is developing a new, computer-mediated process for software development as well as post-deployment software refinement that will take a real bite out of the software crisis. It exploits AI technology to gain "Intelligent Assistance" by capturing the latest software advances in the process, applying automated reasoning methods to insure process integrity and coordinating all software life cycle aspects.

**Knowledge Based Systems Engineering. This area is developing tools for building quality knowledge based systems for large scale applications. Current emphasis is on methods for providing "intelligent" behavior in simulations and on the development of a

laboratory testbed for designing and testing solutions to large knowledge based decision support systems.

****JDL Tri-Service Distributed Computing.** This is a joint development and experimentation effort involving Air Force, Army and Navy which is addressing the development of distributed computing technology. It is based on a distributed testbed with nodes at each of the locations interconnected by the Defense Research Internet and addresses the issues of distributed application development, user interface, distributed database management and fault tolerance.

****Trusted Heterogeneous Architecture (THETA).** A multi-level secure distributed operating system capable of providing a trusted computing base at the B2 level of assurance, which incorporates different types of computers interconnected by a local area network into a single integrated computing environment.

****Acoustic Charge Transport.** ACT is a new type of analog-signal processor being developed for use in advanced performance communications and radar receivers. ACT processors provide the high speed signal processing capability essential to implement more robust communication systems and reduce the size, power and weight of those systems. ACT devices have many military and civilian applications.

****USAF Cooperative RD.** The Directorate sponsors a joint program to develop advanced international communication networks in support of U.S., Canadian, UK, and Australian Air Force communication systems.

****Guard Architecture for Application Portability (GAAP).** This effort will develop a prototype of a highly configurable guard, for a multitude of target user environments and applications. Its configuration will be parameter and module-based to minimize or eliminate software recoding for each user environment. It will also provide a framework for the introduction of new software modules for added functionality, if desired. The prototype will consist of COTS hardware and an integration of COTS, GOTS, and developed software. It will be developed and documented to be accredited at a user site, following initial prototype evaluation.

****Information for the Warrior.** The Department of Defense has a requirement for a wide- bandwidth communications infrastructure to provide Command and Control information to warfighters whenever and wherever required. The U.S. Air Force, in a joint program with the Army and Navy, is developing the technology to provide secure, survivable high-capacity network communications to the warfighters from the point where commercial presence ends. The demonstration of this technology in conjunction with commercial and military off-the-shelf systems constitutes information for the Warrior. The comprehensive, joint program will be executed under the auspices of the Joint Directors of Laboratories (JDL).

****Photonic Communications.** Several optical communications technology development projects are under way to field extremely high performance lightweight communications systems in the 1990s and beyond.

USAFE Guard. This program is designed to partially automate the distribution of large amounts of time-sensitive communications among U.S. Air Forces in Europe. It enables the two-way flow of information between computer systems at different security levels.

Secure, Survivable Communication Networks. The Directorate is involved in a broad-based research and development program to improve the survivability and enhance the performance of Air Force worldwide communications.

Joint Multi-Band Multi-Mode Radio (MBMMR). This is a ARPA-led joint-service program to exploit advanced communications technologies in prototyping a highly programmable multi-band, multi-mode radio. This radio will communicate a variety of Army, Navy, AF and Civil fielded tactical radios. The radio is to be programmable to support new operational requirements, small, easy-to-use, highly supportable and affordable.

Space Communications. Addresses space and ground segment technology development to include radio transceivers, adaptive/multi-beam antennas, terminal (airborne and ground) packages, signal processing and communications processors for military communications using commercial or military SATCOM Systems.

Communications Signal Processing. Develop and apply advanced signal processing algorithms, architectures and devices to provide effective and affordable wireless communications in dynamically changing, interference-rich and high-intercept threat tactical environments. The technology area is focused on exploitation/interference resistant techniques, auto sensing and adaptation, high bandwidth efficiency, modeling/simulation/rapid prototyping, and high performance, low size/weight/power/cost processors/devices.

Distributed Computing Systems. This technology area is developing the mechanisms and prototypes to support the global information processing needs of future C4I systems. Building upon advanced communications networks, these prototypes will provide the seamless information environment to support immediate and location transparent access to data from the sensors, to the decision makers, to the execution elements.

Multi-Level Secure Information Systems. This technology area develops the necessary mechanisms to provide adequate security safeguards for simultaneous access to data at multiple classification levels, resident on a single computer or network of computers, by multiple users who possess different clearances and needs to know.

SPECIAL FACILITIES

The Command, Control and Communications Directorate research is conducted in several specialized facilities, including:

Command and Control Technology Center. A Laboratory facility, managed by the Command, Control and Communications Directorate to host in-house research projects

that require participation by multiple Directorates. The Command and Control Center is electronically interconnected with a number of other Rome Laboratory facilities as well as other national laboratories and universities. It contains state-of-the-art computer processors, as well as advanced information display capabilities. The center complex is used for C4I technology demonstrations and research.

****Distributed Systems Evaluation Environment.** An in-house facility for the development and evaluation of multi-cluster information processing systems, composed of different types of computers interconnected by local area networks, with interconnectivity nationally and internationally by means of the Defense Research Internet. Technologies investigated include distributed operating systems, database management systems, fault tolerance mechanisms, protocols and distributed systems tools.

****Information and Computer Security Testbed.** An in-house facility for the development and evaluation of multi-level security for computers and information handling architectures, including both single host and multi-host distributed information handling systems. Technologies include formal methods for design and verification of secure systems, secure distributed systems, secure database management and certification methodologies.

****Computer Science and Technology Center.** An in-house research and demonstration capability to host work in software engineering and artificial intelligence. Allows engineers to perform in-house research, evaluate contractor-developed software and demonstrate applications of both. Because of the unique network and advanced computer hardware, it is possible to develop and evaluate complex AI systems and software engineering tools and processors. The most striking feature of the Center is the variety and configuration of computer equipment. The facility has a number of different types of machines, all communicating together through several networks. The networks also allow the engineers to utilize Rome Laboratory's resources from microcomputer offices.

****Communications Experimental Facility.** This facility is specifically designed to test and evaluate signal processors, radio equipment, and special antenna in a reflection-free signal chamber.

****Network Design Facility.** This facility contains various switched network testbeds. These include a six node DDN type network, a high speed IP router network, and the Integrated Services Digital Network (ISDN). These networks are used to test and develop future robust protocols and network architectures.

****NYNET.** A New York based network that is a demonstrator of the National Information Infrastructure for the future. Provides connectivity among various academic, government and industry researchers.

****Advanced Multi-Media Information Distribution (AMIDS) Center.** This center simulates a tactical Air Force field operating system. The facility is used to test advanced concepts and new equipment to provide highly reliable, secure, fail-safe communications in a tactical battlefield.

**Multi-Level Security (MLS) Test Facility. This computer facility exists to integrate and test computer systems which connect networks or systems at different security classifications. The testing is done at the unclassified level while the environment may emulate different security levels. The facility provides various networks and dedicated equipment that can be configured to emulate a variety of environments.

**Advanced Displays and Intelligent Interfaces. This facility provides a development, test and evaluation environment for advanced human-computer interface systems including virtual reality systems, high resolution wall displays and non-conventional interaction mechanisms, as well as investigating the most effective ways for the users to utilize the systems.

**Laser Communications Technology Facility. Addresses the evaluation and test of advanced laser communications components to include high-power transmitter sources, receivers, optical components and beam steering devices, as well as the integration of the components into transmitter/receiver terminals. In addition, the facility has the capability to network several terminals together for development/evaluation of acquisition/tracking technology.

**The SHF Antenna Nulling Technology Facility. Addresses the evaluation and test of advanced SHF receiver technology to include beamforming networks and adaptive algorithm development --- subjecting the antenna to a "live" jamming environment. The facility also has the capability to conduct experiments within an anechoic chamber. Distributed antenna configurations can be accommodated.

**Terminal Technology Facility. This facility has a complete fixed SFH ground satellite terminal as well as a palletized, transportable satellite terminal that can be transported by air or truck to remote locations. The facility can be set up to operate as a satellite relay between Rome and many other Air Force sites worldwide when experimental systems need to be tested and evaluated. In addition the facility has an EHF transportable terminal for test and evaluation.

Appendix D:
Electronic Inquiry Form

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ROME LABORATORY TECHNOLOGY -- TRANSFER REQUEST FORM

RL

Please provide the following information so we can help you in a timely manner. Return the completed form via E-mail to the Technology Transfer Office:

Name: Request Date:

Title: E-mail:

Organization:

Street address:

City: State: Zipcode:

Phone number: Fax number:

Company Size (Number of Employees):

1-100
101-500
501 or more

You are seeking:

Information on Technologies or Research
Technology Available for Licensing
Cooperative Research & Development Agreement
Educational Partnership Agreement
Contact with Researchers
Use of Lab Equipment or Facilities

Short Description of Request:

How can Rome Laboratory Best Help You? :

Schedule - Date Needed:

Do You Want This Request Kept Confidential?

Yes
No
No Preference

To deliver this form to the Technology Transfer Office, press this button .

To clear this form, press this button

Appendix E:
TTO Contact Information

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THE TECHNOLOGY TRANSFER OFFICE

RL

CONTACTING THE TECHNOLOGY TRANSFER OFFICE

For more information contact Bill Kaveney at Rome Laboratory.

- **Address**
  Rome Laboratory/XPD
  26 Electronic Parkway
  Rome, NY 13441-4514

- **Telephone**
  - commercial # (315) 330-1905
  - DSN # 587-1905
  - fax # (315) 330-7043

- **Email**
  xpt/inquiry@rl.af.mil
  or just click on this
- **Feedback Form**
  click here

RL

Appendix F:
Technology Promotions

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TECHNOLOGY TRANSFER PROMOTIONS

RL

Technology Promotions *(These images are in a GIF format).*

Rome Laboratory will put your technology needs into focus
The technology behind the Binary Phase-Only Filter (BPOF) can be applied to solve almost any pattern recognition problem you have. Including quality control, bar code recognition, traffic control, robotics, and security systems. The BPOF is currently being used to develop an automatic target recognition systems for the Air Force and for fingerprint identification in law enforcement.

The patented Binary Phase-Only Filter was invented by one of Rome Laboratory's own scientists, and we are now seeking licensing opportunities for this exciting new technology.

In-Depth Technology Focus | Tech Data Sheet

Tomorrow's IC Today by Irvine Sensors
Rome Laboratory and Irvine Sensors worked together to apply advanced packaging technology to stack chips so densely that a 'Virtual Silicon' Integrated Circuit (IC) is created. This approach makes it possible to use the latest 16 Megabit DRAM memories to create a much larger 64 Megabit memory.

Today, Irvine Sensors Corporation is working with IBM to bring 'Virtual' ICs into high volume production. Initially designed for advanced satellite computers, this technology will soon find its way into Supercomputers, Portable PCs, and Engineering Workstations.

Tech Data Sheet | Success Story (1) | Success Story (2)

A Tough ACT to Follow
Rome Laboratory in collaboration with Electronic Decisions, Inc. has helped to produce a breakthrough in analog signal processing -- the Acoustic Charge Transport, or ACT chip.

The advantages seem endless! Over 45 ***billion*** multiply-and-accumulates (MACs) per second. Near gigahertz sampling. Real-time control for flexible, adaptive systems. Single chip, all analog processing avoiding the size and costs of A/D and D/A converters. And the ACT's low power consumption saves tens of hundreds of watts over equivalent digital systems.

Commercial applications seem endless too. Uses include equalization, programmable filtering, pattern matching, electronic decoys, digital audio broadcasting, data links, and communications just to name a few.

Tech Data Sheet | Success Story

Your Voice is Safe with Rome Laboratory
When keeping your conversations secure is important to you, you need Rome Laboratory's Secure Digital Voice Technology.

By using frequency domain speech compression techniques, we have created an entirely new multi-rate coding technology. The Secure Digital Voice's patented technology will allow both the military and civilian sectors to ensure secure communications while greatly increasing channel capacity.

In addition to the Vone(TM) produced by Comtech Labs, other applications for Rome Laboratory's Secure Digital Voice technology include satellite and fail-soft land mobile radio communications. video teleconferencing, and adaptive voice/data networks.

Tech Data Sheet

RL

Appendix G:
POF

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THE PHASE ONLY FILTER (POF)

RL

Rome Laboratory will put your technology needs into focus
The technology behind the Binary Phase-Only Filter (BPOF) can be applied to solve almost any pattern recognition problem you have. Including quality control, bar code recognition, traffic control, robotics, and security systems. The BPOF is currently being used to develop an automatic target recognition systems for the Air Force and for fingerprint identification in law enforcement.

The patented Binary Phase-Only Filter was invented by one of Rome Laboratory's own scientists, and we are now seeking licensing opportunities for this exciting new technology.

Technology Description | Technology Readiness | Commercial Applications | U.S. Patents
Publications | Awards | The Inventor(s) | Contacting TTO

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TECHNOLOGY DESCRIPTION

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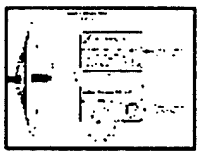
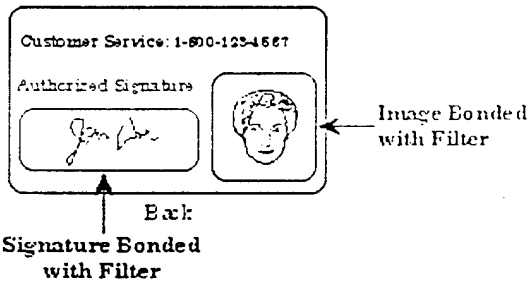
The Phase Only Filter for Counterfeit-Proof Biometric Security

The Phase Only Filter (POF) technology uses complex phase/ amplitude patterns to record a random phase mask containing the security pattern that is then permanently bonded onto the card. The phase filter is invisible to conventional light sources.



When such a card is presented at the point of access the phase mask is read using coherent light and the pattern using optical correlation is compared to the valid pattern. If the pattern recorded on the phase filter on the card correlates to the pattern stored in the reader, the card is deemed authentic. Any attempt to remove or alter the phase filter will destroy the integrity of the security measure thus making it impossible for a counterfeiter to remove the phase mask from one card and place it on another card.



For additional security the phase mask can be placed over a visible security feature such as a picture, fingerprint, signature or hologram. For even more security the primary security feature, such as a finger print or picture can also be encoded on a phase mask.

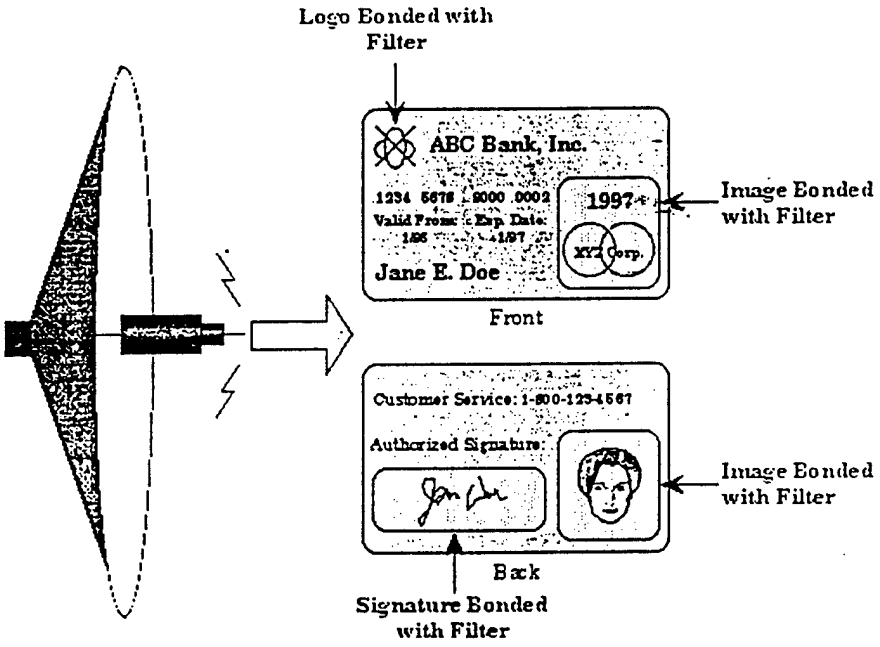
The Phase Only Filter (POF) technology, unlike other currently used security measures such as holograms, cannot be copied by intensity sensitive devices such as scanners and CCD cameras. The recorded pattern on the phase mask cannot be ascertained by looking at the card under a microscope, photographing it, or reading it with a computer scanner.

We propose a new generation of invisible patterns that cannot be seen and cannot be copied by a conventional detector such as the CCD camera. In the mid-1980's we proposed a new method for pattern recognition and target tracking based on the Fourier phase of an object. By object we usually mean a two dimensional image like an enemy target such as a tank or missile. However, it could be a fingerprint, a person's face, the iris of the eye, or some other biometric data. Conventinal methods of pattern recognition use the Fourier phase as well as the amplitude, usually in the form of the traditional Matched Filter. An optical system using only the phase has certain advantages. It is 100% optically efficient - all the light goes through. This means the system can use a low power (milliwatt) drive laser, such as an inexpensive laser diode. The implementation of this principle was highly successful in a field-hardened Optical Correlation system which was built and field tested. We now have extended this basic phase-mask method to the field of optical encryption and security encoding for the biometric information. The way it works is that a two-dimensinal phase mask with up to several millions of pixels is used. It is not holographic.

This technology is an excellent example of dual use technology where technology developed for military purposes can be applied to civilian applications. This technology is applicable to all applications where the authentication of a card, device, or item is of the utmost importance. This technology is unobtrusive in that it is a clear film that can be placed anywhere on an item or document.

RL

GIF image 528x383 pixels http://www.rl.af.mil:8001/Technology/POF/POF-gifs/POF_cards.gif



TECHNOLOGY READINESS

RL

The POF technology is matured and ready for licensing at the present time.

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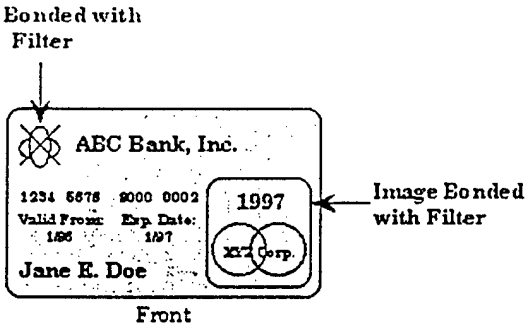
COMMERCIAL APPLICATIONS

RL

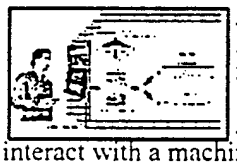
Access Point Fraud Prevention



The use of magnetic stripe cards, smart cards, super smart cards and similar devices will grow as our society moves towards the cashless society. As more and more transactions are conducted though the use of credit cards, ATM cards, debit cards, smart cards, so too will increase the losses associated with the fraudulent use of these cards. Just as security measures have been developed for currency and checks to prevent counterfeiting and fraud, so too must security measures for card based technology be developed.

The best way to stop counterfeiting is to prevent it in the first place. Making the item as counterfeit-proof as possible is probably the best solution. However, as technology advances so does the sophistication of the tools available to and employed by counterfeiters. Holograms have been added to credit cards in an attempt to foil the credit card counterfeiter. Advances in CCD camera technology have enabled the counterfeiter to produce cards with holograms that look genuine to the naked eye.

What is needed is a machine readable system at the point of access to detect and prevent the use of fraudulent cards, be they credit, ATM, or smart cards. Rome Laboratory (RL), the United States Air Force's premier command, control, communications, computing and intelligence (C4I) laboratory has developed such a technology based on the phase only filter and optical processing.



A machine readable technology based on the POF would allow the detection of fraudulent cards at the point of access thus preventing the type of crime as illustrated by the following case of ATM fraud.

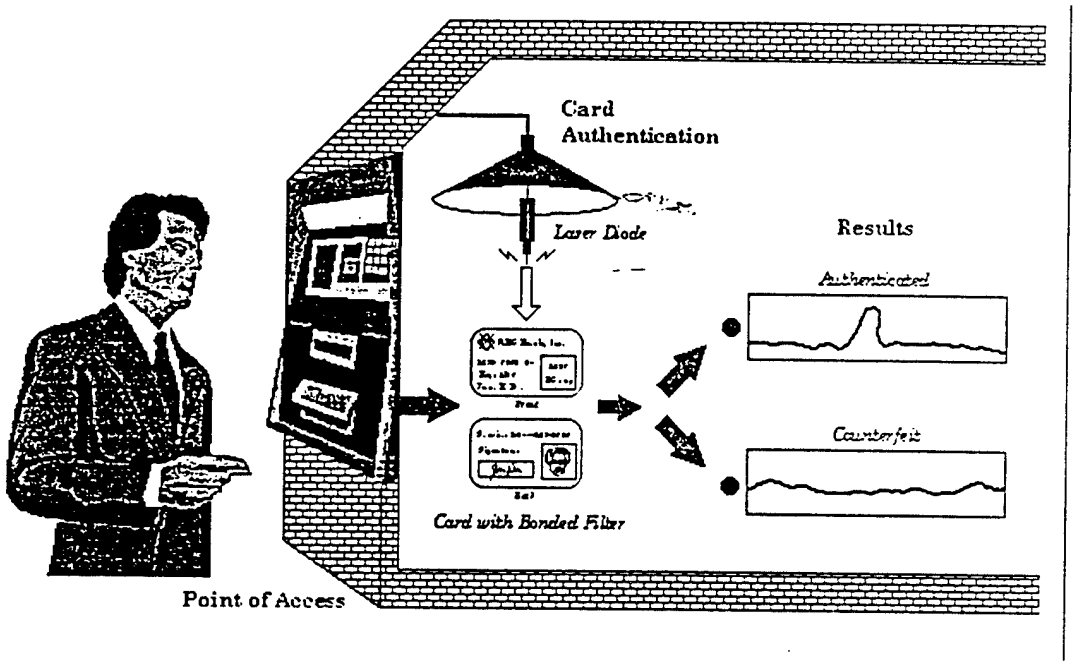
ATM fraud is very impersonal. The perpetrator committing the crime needs only to interact with a machine. There is no actual verification of whether the card is real or not. The actual card presented to the ATM may in actuality be a blank card or a forged card with the magnetic strip encoded with the appropriate access information.

If ATM cards were to have a security measure such as the POF, then the type of crime as illustrated by the ATM fraud case would be prevented. The card presented at the point of access would be authenticated using POF technology.

RL

GIF image 620x376 pixels

http://www.rl.af.mil:8001/Technology/POF/POF-gifs/POF_ATM.gif



Technology Transfer Technology Transfer Technology Transfer

UNITED STATES PATENTS

RL

List of Patents With Abstracts and Figures

Click on patent title for full text

Single SLM Joint Transform Correlators (#5,040,140)

Abstract

A simple, low cost, high performance joint Fourier transform correlator, which requires only a single spatial light modulator, is disclosed. Input and reference images are recorded upon a single phase modulating SLM, and a lens produces a first joint Fourier transform of the images upon an electro-optic sensor. The first Fourier transform is binarized and recorded upon the single SLM electronically, and the same lens produces a second Fourier transform to form an image correlation signal at a correlation plane. Also, recordation of the input and reference images and recordation of the joint Fourier transform upon the single SLM may be performed optically rather than electronically.

Figures

Figure 1 Illustrates a Prior Art Correlator

Figure 2 Illustrates the First Embodiment of the Invention Wherein the First Fourier Transform is Recorded Upon the SLM Electronically

Figure 3 Illustrates the Second Embodiment Wherein the First Fourier Transform is Recorded Upon the SLM Optically

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Amplitude Encoded Phase-Only Filters for Optical Correlators (#5,024,508)

Abstract

Method allows a first phase-only optical correlator filter function to be written on an amplitude modulating device such as a spatial light modulator (SLM) by applying a bias term to the phase only filter function great enough to obtain a second amplitude encoded filter function, for use with a more economical amplitude responsive SLM.

Figures

FIG. 1 discloses an optical correlator; and

FIGS. 2a-2d disclose various data in graphic form.

Method of Enhancing the Signal to Noise Ratio of an Image Recognition Correlator (#4,826,285)

Abstract

Method of producing an enhanced output correlation signal from an image matching correlator includes the steps of further transforming data representing an input image to produce a transformed image, multiplying the transformed image by at least one reference filter function representing a reference image to be compared with the input image to produce a product signal, inverse fourier transforming the product signal to product the output correlation signal, and introducing phase distortions within the reference filter function, sufficient to greatly enhance peak values and narrow the area of the correlation peak of the output correlation signal. The method may utilize optical or digital electronic correlation and transformation.

Figures

- FIG. 1 discloses an optical correlator in accordance with the present invention.
- FIGS. 2, 3 , ---- 5, 6, 8 and 9 disclose plots of the SNR v. phase distortion for the uncompensated and compensated conditions.
- FIG. 4 discloses plots of relative area of correlation peak v. phase distortion.
- FIGS. 7(a)-7(d) illustrate correlation output signal response for increasing phase distortion.
- FIG. 10 discloses a flow chart for the non-optical embodiment of the invention.

Binary Phase-Only Optical Correlation System (#4,765,714)

Abstract

A binary phase-only optical correlation system incorporating therein a binary phase-only filter. The binary phase-only optical filter is made by mathematically generating preselected phase-only information by a fast Fourier Transform technique. This generated phase-only information is binarized into a function having two values. This binarized function is utilized to produce a mask which in turn is used in conjunction with an appropriate optical substrate to produce the binary phase-only filter. The manufacture of the binary phase-only filter is substantially easier than the production of a phase-only filter yet virtually the same correlation results when the binary phase-only filter when it is used in an optical correlation system.

Figures

- FIG. 1 is a graphic representation of the functions f(x) and g(x) displaced by a distance xo during correlation;
- FIG. 2 is a graphic representation of the functions f(x) andg(x) beginning to overlap each other during correlation;
- FIG. 3 is a graphic representation of the correlation of the functions f(x) and g(x);
- FIG. 4 is a schematic illustration of the basic components of the Vander Lugt optical correlator;
- FIG. 5 is a schematic representation of the binary phase-only correlation system of the present invention;
- FIG. 6 is a graphic representation of the binarization (quantization) of phase only information to two values, 0 and pi during the initial step of fabricating the binary phase-only filter of the present

invention;

- FIG. 7 is a pictorial representation of the production of the mask for the binarized phase-only filter of the present invention;
- FIG. 8 is a cross-sectional side elevational view of the mask produced by the step illustrated in FIG. 7 after photoresist development;
- FIG. 9 is a cross-sectional view of the mask of FIG. 8 utilized in conjunction with an appropriate optical substrate to transfer the binary pattern from the mask of FIG. 8 to the substrate;
- FIG. 10 is a cross-sectional view of the binary phase-only filter of this invention being produced by the step of ion bombardment reactive ion etching, sputter etching, or any other etching technique;
- FIG. 11 is a cross-sectional view of the binary phase-only filter of the present invention;
- FIG. 12 is a three dimensional graphic representation of the correlation of an object with a phase-only optical correlation system; and
- FIG. 13 is a three dimensional graphic representation of the correlation of an object with the binary phase-only correlation system of this invention.

Phase-Only Optical Filter for Use in an Optical Correlation System (#4,588,260)

Abstract

A phase-only optical filter capable of being utilized within a phase-only optical correlation system. The phase-only filter is made by mathematically generating preselected phase-only information by a Fast Fourier Transform technique. This generated phase-only information is transferred onto an unexposed holographic film. Thereafter, the film is developed and subsequently bleached. The resultant bleached film is the phasse-only filter which, when utlized in a correlation system, provides substantially 100% utilization of the source of electromagnetic radiation during the correlation process. Click here for full patent text and diagrams.

Figures

- FIG. 1 is a graphic representation of the functions f(x) and g(x) displaced by a distance tau during correlation;
- FIG. 2 is a graphic representation of the functions f(x) and g(x) beginning to overlap each other during correlation;
- FIG. 3 is a graphic representation of the correlation of the functions f(x) and g(x);
- FIG. 4 is a schematic illustration of the basic components of the Vander Lugt optical correlator;
- FIG. 5 is a schematic representation of the phase-only correlator filter of the present invention utilized within a phase-only optical correlation system;
- FIGS. 6A and 6B illustrate the letters O and G, respectively, which are utilized to demonstrate the effectiveness of the phase-only optical correlation system of this invention;
- FIG. 7 is a three dimensional graphic representation of the correlation of the letter G utilizing a conventional or classical matched filter under noiseless conditions;

- FIG. 8 is a three dimensional graphic represention of the correlation of the letter G utilizing the phase-only filter of the present invention under noiseless conditions;
- FIG. 9 is a three dimensional graphic represention of the correlation of the letter G utilizing an amplitude-only filter under noiseless conditions;
- FIG. 10 is a three dimensional graphic representation of the correlation of the letter G utilizing a conventional or classical matched filter underconditions of noise;
- FIG. 11 is a three dimensional graphic representation of the correlation of the letter utilizing the phase-only correlation filter of this invention under conditions of noise; and
- FIG. 12 is a graphic representation, for comparison purposes, of the autocorrelation outputs of the phase-only filter of this invention and the classical matched filter, respectively.

United States Patent

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SINGLE SLM JOINT TRANSFORM CORRELATORS

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ASSIGNEE: The United States of America as represented by the Secretary of the Air Force, Washington, District of Columbia

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FIELD OF SEARCH: 364/819-822; 350/3.6, 162.12, 162.13, 162.14; 382/42

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ABSTRACT:
A simple, low cost, high performance joint Fourier transform correlator, which requires only a single spatial light modulator, is disclosed. Input and reference images are recorded upon a single plane

modulating SLM, and a lens produces a first joint Fourier transform of the images upon an electro-optic sensor. The first Fourier transform is binarized and recorded upon the single SLM electronically, and the same lens produces a second Fourier transform to form an image correlation signal at a correlation plane. Also, recordation of the input and reference images and recordation of the joint Fourier transform upon the single SLM may be performed optically rather than electronically.

34 Claims, 3 Drawing Sheets

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

BACKGROUND OF THE INVENTION

The present invention relates to the field of optical joint transform correlators. Joint transform correlators (JTC) can be used to match an input image being viewed in real time with a plurality of reference images. See U.S. Pat. No. 4,357,676 issued to Hugh Brown, and U.S. Pat. No. 4,695,973 issued to F. T. S. Yu.

It has been shown previously that binary joint transform correlators can produce very good correlation performance. See B. Javidi and C. J. Kuo, "Joint Transform Image Correlation using a Binary Spatial Light Modulator at the Fourier Plane," Applied Optics, Vol. 27, No. 4, 66-665 (1988); and see B. Javidi and S. F. Odeh, "Multiple Object Identification by Bipolar Joint Transform Correlation," Optical Engineering, Vol 27, No. 4, 295-300 (1988). The binary JTC uses nonlinearity at the Fourier plane to binarize the Fourier transform interference intensity to only two values, + 1 and - 1. The performance of the binary JTC has been favorably compared to that of the classical JTC, (C. S. Weaver and J. W. Goodman, "A Technique for Optically Convolving Two Functions," Applied Optics, Vol. 5, No. 7, 1248-1249 (1966)) in the areas of light efficiency, correlation peak to sidelobe ratio correlation width, and cross-correlation sensitivity. The motivation for binarizing the interference intensity has been the good correlation performance obtained by binary phase-only filter-based optical correlators. See J. L. Horner and P. D. Gianino, "Phase-only matched filtering," Applied Optics, Vol. 23, No. 6,812-816 (1984); J. L. Horner and J. R. Leger, "Pattern recognition with binary phase-only filters," Applied Optics, Vol. 24, No. 5, 609-611 (1985); and J. L. Horner and H. 0. Bartelt, "Two-bit correlation," Applied Optics, Vol. 24, No. 18, 2889-2893 (1985).

SUMMARY OF PREFERRED EMBODIMENTS OF THE INVENTION

It is an object of the present invention to provide a joint transform correlator which requires only a single spatial light modulator in contrast with prior art correlators. This results in significant reduction in cost, size and complexity of the correlator, which additionally outperforms prior art systems.

Input and reference images are recorded upon a single phase modulating SLM and a lens produces a first joint Fourier transform of the images upon an electro-optic sensor. The first transform is binarized and recorded upon the single SLM electronically, and the same lens produces a second Fourier transform to form an image correlation signal at a correlation plane.

In a second embodiment of the invention, recordation of the input and reference images and recordation of the joint Fourier transform upon the single SLM are performed optically rather than electronically.

Other objects, features and advantages will become apparent upon study of the following description, taken in conjunction with the drawings in which:

Figure 1 Illustrates a Prior Art Correlator

Figure 2 Illustrates the First Embodiment of the Invention Wherein the First Fourier Transform is Recorded Upon the SLM Electronically

Figure 3 Illustrates the Second Embodiment Wherein the First Fourier Transform is Recorded Upon the SLM Optically

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

A prior art joint transform image correlator is shown in FIG. 1. Plane P1 is the input plane that contains the reference signal and the input signal displayed on an electrically addressed SLM 1. The images enter the input SLM and are illuminated by coherent light CL, and are then Fourier transformed by lens FTL1. The interference between the Fourier transforms is produced at plane P2, coincident with an electro-optic image sensor such as a charge coupled array or device (CCD) 3. In the classical joint Fourier transform correlator, a second SLM 2 is located at plane P3 to read out the intensity of the Fourier transform interference. The correlation functions can be produced at plane P4 by having lens FTL2 take the inverse Fourier transform of the interference intensity distribution at plane P3.

The reference and the input signals located at plane P1 are denoted by S1(x + x o ,y) and S2(x-x o ,y), respectively. The light amplitude distribution at the back focal plane P2 of the transform lens FTL1 is the interference between the Fourier transforms of the input and reference functions, i.e.,

$$G(\alpha,\beta) = S_1\left(\frac{2\pi}{\lambda f}\alpha, \frac{2\pi}{\lambda f}\beta\right)\exp\left(-i\frac{2\pi}{\lambda f}x_o\alpha\right) + S_2\left(\frac{2\pi}{\lambda f}\alpha, \frac{2\pi}{\lambda f}\beta\right)\exp\left(i\frac{2\pi}{\lambda f}x_o\alpha\right). \quad (1)$$

where (alpha , beta) are the spatial frequency coordinates. S1(.) and S2(.) corresond to the Fourier transforms of the input signals S1(x,y) and S2(x,y), respectively, f is the focal length of the transform lens, and lambda is the wavelength of the illuminating coherent light.

The Fourier transform interference intensity distribution can be written as:

$$|G(\alpha,\beta)|^2 = \left|S_1\left(\frac{2\pi}{\lambda f}\alpha,\frac{2\pi}{\lambda f}\beta\right)\right|^2 + \left|S_2\left(\frac{2\pi}{\lambda f}\alpha,\frac{2\pi}{\lambda f}\beta\right)\right|^2 + S_1\left(\frac{2\pi}{\lambda f}\alpha,\frac{2\pi}{\lambda f}\beta\right)S_2^*\left(\frac{2\pi}{\lambda f}\alpha,\frac{2\pi}{\lambda f}\beta\right)\exp\left(-i\frac{2\pi}{\lambda f}2x_0\alpha\right) + S_1^*\left(\frac{2\pi}{\lambda f}\alpha,\frac{2\pi}{\lambda f}\beta\right)S_2\left(\frac{2\pi}{\lambda f}\alpha,\frac{2\pi}{\lambda f}\beta\right)\exp\left(i\frac{2\pi}{\lambda f}2x_0\alpha\right). \quad (2)$$

In the classical case, the the last two terms in the inverse Fourier transform of Eq. (2) can produce the correlation signals at the output plane. The output signals in plane P4 are

$$g(x',y') = R_{11}(x',y') + R_{22}(x',y') - R_{12}(x',y') - R_{12}(x'-2x_0,y') - R_{21}(x'-2x_0,y'), \quad (3a)$$

where

$$R_{ij}(x',y') = \int s_i(x'-x,y'-y)s_j^*(x,y)dx\,dy,\ i,j=1,2. \quad (3b)$$

and the terms R21 and R12 are the desired correlation signals.

The amplitude of the input signal and the reference signal are binarized to two values (+ 1 and - 1) to increase the light efficiency at the input plane. The threshold for the binarization of the input signals is typically chosen to be the average pixel intensity value.

The output correlation signals for the binary input classical JTC case are

$$g^b(x',y') = R_{11}^b(x',y') + R_{22}^b(x',y') - R_{12}^b(x'-2x_0,y') - R_{21}^b(x'+2x_0,y') \quad (4)$$

Here, R ijb corresponds to the correlation between the thresholded input and reference signals [see original for Equation 3b].

In the binary JTC, the Fourier transform interference intensity provided by CCD array is thresholded before the inverse Fourier transform operation is applied. The CCD array at the Fourier plane is connected to SLM 2 through a thresholding network 7 and interface 9 so that the binarized interference intensity distribution can be read out by coherent light. The interference intensity is binarized according to the following equation

$$H(\alpha,\beta) = \begin{cases} +1 \text{ if } |G(\alpha,\beta)|^2 \geq \tau_{th} \\ -1 \text{ otherwise.} \end{cases} \quad (5)$$

Here, H(alpha , beta) is the binarized interference intensity, G(alpha ,

beta) <2 > is the interference intensity given by Eq. (2), and v tb is the threshold value. The threshold for binarization of the Fourier transform interference intensity can be set by making the histogram of the pixel values of the interference intensit and then picking the median. The correlation signals can be produced by taking the inverse Fourier transform of the binarized interference intensity given by Eq. (5)

$$s(x',y') = \int H(\alpha,\beta)\exp[i(x\alpha + y\beta)]d\alpha d\beta. \quad (6)$$

A recent theoretical study shows that the correlation signal obtained by this technique is similar to what would be obtained by inverse filtering in the Fourier transform plane.

As shown in FIG. 2, single SLM 13 is used to display both the thresholded input signals and the thresholded Fourier transform interference intensity. The thresholded input and reference signals enter SLM 13 via switches S1 and S2, which SLM operates in the binary mode. More specifically, an input image may be viewed and converted into electrical signals by a CCD camera 17, which signals are preconditioned by unit 19. The input signals are energy normalized to avoid false correlations; that is substantial swings in the light intensit of the image are eliminated. The image data is also binarized by conventional thresholding to match the input requirements of SLM 13. Algorithms for performing these functions are well known in the art.

A library of reference images from source 20 are recorded in SLM 13 to be correlated with the input signal, as described in the aforesaid U.S. Pat. No. 4,695,973. Switch S2 would be in the closed position during this operation. The interference pattern formed at plane 24, between the Fourier transforms of the input and reference signals is obtained using lens (transformation means) 21 and a CCD image sensor 23, to produce the transform interference intensity distribution. The interference intensity is then thresholded by unit 25 to only two values, + 1 and - 1, S3 being in the A (acquire) position. The binarized interference intensity is then recorded on the same SLM 13 and FTL lens 21 takes the inverse Fourier transform of the thresholded interference intensity pattern in SLM 13.

More specifically, SLM 13 is of the binary phase modulating type, where each pixel modulates the light going through by + 1 or - 1. With switch S1 in the A, or acquire, position, the binarized input signal from unit 19 is written on the SLM. The input signals are thresholded according to a predetermined threshold value (v ti) to only two values, + 1 and - 1. Coherent light 22 incident on the SLM in conjunction with FTL lens 21 produces the first Fourier transform interference pattern of the binarized images:

$$|G_b(\alpha,\beta)|^2 = \left|S_{1b}\left(\frac{2\pi}{\lambda f}\alpha, \frac{2\pi}{\lambda f}\beta\right)\right|^2 + \left|S_{2b}\left(\frac{2\pi}{\lambda f}\alpha, \frac{2\pi}{\lambda f}\beta\right)\right|^2 + S_{1b}\left(\frac{2\pi}{\lambda f}\alpha, \frac{2\pi}{\lambda f}\beta\right)S_{2b}^*\left(\frac{2\pi}{\lambda f}\alpha, \frac{2\pi}{\lambda f}\beta\right)\exp\left(-i\frac{2\pi}{\lambda f}2x_0\alpha\right) + S_{1b}^*\left(\frac{2\pi}{\lambda f}\alpha, \frac{2\pi}{\lambda f}\beta\right)S_{2b}\left(\frac{2\pi}{\lambda f}\alpha, \frac{2\pi}{\lambda f}\beta\right)\exp\left(i\frac{2\pi}{\lambda f}2x_0\alpha\right). \quad (7)$$

where S 1b (.) and S 2b (.) are the Fourier transforms of the binarized I nput signals S 1b (.) and S 2b (.), respectively. CCD image sensor 23 detects this intensity pattern, sends it to thresholding circuit 25 where it is thresholded about the value v u . The thresholded interference intensity is

$$H_b(\alpha,\beta) = \begin{cases} +1 \text{ if } |G_b(\alpha,\beta)|^2 \geq v_u \\ -1 \text{ otherwise.} \end{cases} \quad (8)$$

where v u is the threshold value used to binarize the interference intensity. It is noted that v u is different from v tb used in Eq. (5).

The binarized Fourier transform interference intensity array is temporarily stored in a conventional frame grabber or buffer 27, which constitutes a second recording means. Timer 29 now switches S1 and S3 to the C, or correlate, position and S2 is opened. The data array in frame buffer 27 is now recorded on the SLM via 31, where again it binary modulates the phase of the incident coherent light. FTL Lens 21 now takes a second Fourier transform and produces a (inverted) correlation signal in the Fourier plane 24 where it is read out by CCD detector 23 and can be displayed on a TV monitor 33, as S3 was switched to the C (correlate) position. If the overall speed of the correlator is to be the standard TV frame rate, then timing circuit 29 will operate at twice the TV frame rate, since it takes two switching sequences to produce one correlation. We have tested four cases of JTC: (1) the classical JTC which does not use thresholding at the input plane nor at the Fourier plane, (2) JTC that uses thresholding at the input plane to binarize the input signals, (3) binary JTC that uses thresholding at the Fourier plane to binarize the interference intensity, and (4) single SLM JTC of the above described embodiment of the present invention that employs thresholding at both the input plane and the Fourier plane to binarize the input signals and the Fourier transform interference intensity, respectively.

We used a 512 x 512 point 2-D fast Fourier transform (FFT) to study the performance of the proposed systems, and the results were plotted using a 3-D plotting subroutine. The median of the normalized pixel values of the input signals is 0.334. The median of the pixel values of the interference intensity is 1.14 x 10<- 6 > when the input is not binarized and is 9.65 x 10<- 5 > when the input is binarized.

Table I below illustrates the results of the correlation tests for the four JTC configurations. In this table, R o <2 > is the correlation peak intensity relative to that of the classical correlator with continuous input normalized to unity, R o <2> /SL<2 > is the ratio of the correlation peak intensity to the maximum correlation sidelobe intensity, FWHM is the full correlation width at half maximum, and CW is the full correlation width. FWHM is determined by evaluating the points where the correlation intensity drops to one-half of its peak value, and CW is determined by evaluating the points where the correlation intensity drops to the first minimum.

The signal-to-noise ratio (SNR) is defined as the ratio of the correlation peak amplitude to the RMS value of the noise, i.e.,

$$SNR = \frac{[R(x_i,y_j)]_{max}}{\left[\sum_{i=1}^{N_i}\sum_{j=1}^{N_j}|n(x_i,y_j)|^2/N_i N_j\right]^{\frac{1}{2}}} \quad (9)$$

where [R(x i ,y j)] max is the correlation peak amplitude, n(x i ,y j) is the noise amplitude outside of the FWHM response of the correlation peak. and N i and N j are the total number of pixels in this sample.

TABLE 1

Case	Joint Transform Correlator*	Correlation results. R_o^2	R_o^2/SL^2	SNR	FWHM (x', y')	CW (x', y')
1.	Classical JTC. Continuous input signal and nonbinarized FTII	1.00		5.67	(36, 40)	(96, 114)
2.	Classical JTC. Binarized input signal and nonbinarized FTII	27.57	3.35	11.12	(1, 3)	(12, 11)
3.	Binary JTC. Continuous input signal and binarized FTII	1.18×10^6	65.98	26.65	(1, 1)	(3, 3)
4.	Single SLM correlator. Binarized input signal and binarized FTII	2.81×10^6	105.83	33.77	(1, 1)	(3, 3)

It can be seen from Table 1 that the best results are obtained for the single SLM correlator [case 4]. i.e , when both the input signals and the Fourier transform interference intensity are binarized. The second best results are obtained by the binary JTC where the Fourier transform interference intensity is binarized [case 3]. The classical JTC which does not use thresholding at the Fourier plane [case 1] produces the worst results. Some improvement in the performance of the classical JTC can be obtained by binarizing the input signals [case 2]. A similar result was described in the above cited article by Bartelt and Horner.

Table I shows that the single SLM JTC of the first embodiment of the invention has a significantly higher correlation peak intensity compared to that of the classical JTC. The classical JTC has a correlation peak intensity of unity, whereas the single SLM JTC has a peak intensity value of 2.81×10^6. The detector output voltage can be expected to be higher by the same factor, all other things being equal. This is important for reducing the effects of the detector noise. The correlation sidelobes were reduced considerably for the single SLM JTC case. The classical JTC has a peak intensity to sidelobe

intensity ratio of 1.00, whereas the single SLM JTC has a peak to sidelobe ratio of 105.83.

It is evident from Table I that binarizing the interference intensity has resulted in a significant reduction in the correlation width and has produced impulse-like autocorrelation functions. The classical JTC has a FWHM of 36 x 40 pixels and a correlation width of 96 x 114 pixels in the (x',y') directions. The single SLM JTC has a FWHM and a correlation width of 1 x 1 pixels in the (x',y') directions.

In summary, a new optical correlator architecture is thus disclosed employing only a single SLM. as compared to the two SLM required in the original JTC. The input signal and the Fourier transform interference intensity are binarized so that a binary SLM can be used to present the input signal and the transform interference intensity. The performance of this single SLM JTC was compared by computer simulations to that of the classical JTC with continuous inputs, the classical JTC with binarized inputs, and the JTC with binarized interference intensity. The results for the four types of correlators are listed in Table I. It was found that the performance of the single SLM JTC of this embodiment of the invention is superior to the other types of correlators. The single SLM JTC has correlation peak intensity 2.81 x 10<6 > times greater, an autocorrelation peak to sidelobe ratio 105.83 times higher, a SNR 6 times higher, and a FWHM 38 times narrower than those produced by the classical JTC. The correlator introduced here employs only a single binary phase-only SLM which provides a significant reduction in cost, size, and complexity of the system. Furthermore. since the SLMs are pure phase devices, the light efficiency of the system is excellent. With a recently introduced technique of amplitude encoding, it may be possible to use a far less expensive binary amplitude encoded SLM rather than the more costly standard phase modulating SLM. See U.S. Pat. application No. 07/335,635, entitled "AMPLITUDE ENCODED PHASE ONLY FILTER," filed by Joseph Horner. There would also be a reduction in the memory space required to store the binary reference signals as compared to storing the continuous function reference images. The single SLM correlator introduced here is compatible withcurrent SLMs which work well in the binary mode. The new binary input/binary interference intensity JTC technique introduced here can be used in digital pattern recognition systems using a digital computer and a FFT program. The first embodiment of the present invention is also described in an article authored by the inventors in "Applied Optics" Vol. 28, No. 5; 1 Mar. 1989.

FIG. 3 illustrates a second embodiment of the present invention utilizing an optically addressed SLM 47. Optical input image 43 and reference image 41 are recorded upon SLM 47, upon the opening of shutter 45. Lens L1 focuses these images upon the face of SLM 47 via beamsplitter BS1.

Coherent light from laser source 49 is reflected from beam-splitter BS2 and reads out the aforesaid images in the SLM. This image modulated light propagates back through BS2 and through Fourier transform lens L2. The light is now folded around by three mirrors, M1, M2, M3, and by BS1, so that the squared value of the Fourier transform of the joint input signals is recorded on single SLM 47. The lens L2 again takes the Fourier transform of the squared value of the joint transform, since this optically addressed SLM only responds to the intensity of the light incident on it, and this light is deflected by mirrors M1 and M2 onto BS3, which deflects some of this light onto plane P1, which is the correlation plane. Three distinct and spatially separated signals appear here; an on-axis or DC term which is of no particular interest, and two indentical off-axis terms which represent the mathematical correlation between the input and the reference signals.

It may be noted that there is no equivalent in FIG. 3 to the intermediate frame buffer 27 of FIG. 2. Good optical correlation spots will continue to be produced at the correlation plane P1 even through the images 41 and 43 have not been erased from SLM 47, since the Fourier transform light patterns are far stronger than the image signals.

In the first embodiment of the invention, binarizing the input and Fourier transforms is greatly preferred, and may also be employed in the second embodiment. However, it should be appreciated that the "folded back" (in time or space) configurations of FIG. 2 and 3, enable the use of a single SLM to effect substantial savings, and that other less preferred embodiments do not absolutely require such binarization. Thus the scope of the invention is to be defined solely by the terms of the following claims and art recognized equivalents.

We claim:

1. A joint Fourier transform correlator comprising:

(a) first recording means for recording an input image and a reference image upon a sngle SLM during a first recording interval;

(b) transformation means for thereafter producing a first Fourier transform of said input and reference image recorded upon said single SLM;

(c) second recording means including means for thereafter recording said first Fourier transform upon said single SLM in place of said input image and said reference image during a second recording interval following said first recording interval; and
(d) correlation signal producing means including said transformation means for producing a second Fourier transform of said first Fourier transform recorded upon said SLM.

2. The correlator of claim 1 wherein said second recording means includes an electro-optic sensor and an electronic buffer storage means coupled between said electro-optic sensor and said SLM.

3. The correlator of claim 2 wherein said SLM modulates the phase of light outputted therefrom.

4. The correlator of claim 3 wherein said electro-optic sensor records both said first and second Fourier transform.

5. The correlator of claim 2 wherien said electro-optic sensor records both said first and second Fourier transform.

6. The correlator of claim 2 wherein said transformation means is an integral part of said correlation signal producing means so that the same transformation means produces both said first and second Fourier transform.

7. The correlator of claim 6 wherein said electro-optic sensor records both said first and second Fourier transform.

8. The correlator of claim 1 further including means for binarizing said first Fourier transform before being recorded upon said SLM.

9. The correlator of claim 8 wherein said first recording means includes

means for binarizing said input image and said reference image.

10. The correlator of claim 9 wherein said SLM modulates the phase of light outputted therefrom.

11. The correlator of claim 9 wherein said transformation means is an integral part of said correlation signal producing means so that the same transformation means produces both said first and second Fourier transform.

12. The correlator of claim 11 wherein said transformation means comprises an optical lens.

13. The correlator of claim 8 wherein said SLM modulates the phase of light outputted therefrom.

14. The correlator of claim 1 wherein said first recording means includes means for binarizing said input image and said reference image.

15. The correlator of claim 14 wherein said SLM modulates the phase of light outputted therefrom.

16. The correlator of claim 1 wherein said SLM modulates the phase of light outputted therefrom.

17. The correlator of claim 16 wherein said transformation means is an integral part of said correlation signal producing means so that the same transformation means produces both said first and second Fourier transform.

18. The correlator of claim 17 wherein said transformation means comprises an optical lens.

19. The correlator of claim 1 wherein said transformation means is an integral part of said correlation signal producing means so that the same transformation means produces both said first and second Fourier transform.

20. The correlator of claim 19 wherein said transformation means comprises an optical lens.

21. The correlator of claim 1 wherein said transformation means comprises a source of coherent light for illuminating said SLM together with optical lens means for producing said first Fourier transform, and said second recording means includes optical relay means for recording said first Fourier transform upon said SLM.

22. The correlator of claim 21 wherein said correlation signal producing means includes said optical lens means so that said lens means produces both said first and second Fourier transform.

23. The correlator of claim 22 wherein said correlation signal producing means includes a beamsplitter included within said optical relay means for retrieving a correlation signal.

24. The correlator of claim 23 wherein said SLM modulates the phase of light outputted therefrom.

25. The correlator of claim 22 wherein said SLM modulates the phase of light outputted therefrom.

26. The correlator of claim 21 wherein said correlation signal producing means includes a beamsplitter included within said optical relay means for retrieving a correlation signal.

27. The correlator of claim 26 wherein said SLM modulates the phase of light outputted therefrom.

28. The correlator of claim 21 wherein said SLM modulates the phase of light outputted therefrom.

29. A method of performing joint Fourier transform correlation of an input image and a reference image, enabling the use of only one SLM comprising the steps of:

(a) providing a single binary phase modulating SLM;

(b) recording input and reference images upon said binary phase modulating SLM;

(c) thereafter producing a first Fourier transform of the input and reference images recorded upon said binary phase modulating SLM;

(d) binarizing said first Fourier transform;
(e) thereafter recording said first Fourier transform binarized in accordance with step (d) upon said single binary phase modulating SLM in place of said input and reference images; and

(f) producing a second Fourier transform of said first Fourier transform stored in said single SLM for indicating the degree of similarity between the input and reference image.

30. The method of performing wherein step (b), (d), and (e) are performed electronically.

31. The correlator of claim 30 wherein said first recording means includes means for binarizing said input image and said reference image.

32. The method of claim 29 wherein steps (b) and (e) are performed optically.

33. The correlator of claim 32 wherein said first recording means includes means for binarizing said input image and said reference image.

34. The method of claim 29 wherein steps (c) and (f) are performed by a single optical lens means.

PUBLICATIONS

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Phase Only Filter (POE) Technical Papers

TABLE OF CONTENTS

Javidi, B., Li, Jian, Fazlollahi, A.H., Horner, J.(1995) Binary nonlinear joint transform correlator performance with different thresholding methods under unknown illumination conditions. *Applied Optics* **34 (5), 886-896.**

Abstract

The correlation performance of binary joint correlators with unknown input-image light illumination is investigated for different thresholding methods used in the Fourier plane. It is shown that a binary joint transform correlator that uses a spatial frequency dependent frequency dependent function for binarization of the joint power spectrum is invariant to uniform input-image. Computer simulations and optical experimental results are provided.

□ **Javidi, Bahram & Horner, Joseph L. (1994). Optical pattern recognition for validation and security verification.** ***Optical Engineering*** **33 (6), 1752-1756.**

Abstract

We propose an idea for security verification of credit cards, passports, and other forms of identification so that they cannot easily be reproduced. A new scheme of complex phase/amplitude patterns that cannot be seen and cannot be copied by an intensity-sensitive detector such as a CCD camera is used. The basic idea is to permanently and irretrievably bond a phase mask to a primary identification amplitude pattern such as a fingerprint, a picture of a face, or a signature. Computer simulation results and tests of the proposed system are provided to verify that both the phase mask and the primary pattern are separately readable and identifiable in an optical processor or correlator.

Tuckerman, D., Benson, D., Moore, H., Horner, J. (1994) A high performance second-generation SPARC MCM. Intl Conference & Exhibition Multichip Modules Denver, Colorado 13-15 April 1994 (Reston, VA:ISHM-Microelectronics Society) *SPIE Proceedings* Vol. 2256, 314-319.

Abstract

ROSS Technology, Inc., and nCHIP, Inc., have successfully produced a second-generation SPARC processor multichip module (MCM). Based on ROSS' hyperSPARC architecture, the module sets a new standard for performance in the SPARC marketplace. The MCM is packaged in a 45 mm-square 256-lead, ceramic quad flatpack carrier, and is footprint-compatible with ROSS' current SPARC MCM, the CYM6111. However, the new module runs at clock speeds in excess of 80 MHz, more than twice the that of the CYM6111, and will offer 3-5 times the performance in most applications. The full module contains six CMOS chips: a CPU containing both integer and floating point ALUs, a cache controller/memory management unit, and four cache RAM chips. Each chip uses both 3.3 and 5.0 volt power supplies, so the MCM substrate incorporates a split. The chips are interconnected using nCHIP's nC1000 substrate technology, which incorporates aluminum interconnect, SiO2 dielectric, and an integral decoupling capacitator. ROSS' multichip design strategy does not depend on massive integration or complex fabrication processes: similarly, the nCHIP nC1000 substrate process is based on a robust, IC-like technology. This combination provides excellent manufacturability and allows a fast production ramp into high volume.

Javidi, B. & Horner, J.L., editors. (1994) ***Real- time optical information processing.*** **London: Academic Press.**

Abstract

The following topics were dealt with: pattern recognition and image processing; neural network; systems; hardware; and application.

Cohn, R.W., Horner, J.L. (1994) Effects of systematic phase errors on phase-only correlation. ***Applied Optics*** **33(23), 5432-9.**

Abstract

The performance of phase-only optical correlators is usually reduced if the filter-plane phase differs from that prescribed for the classical matched filter. Current spatial light modulators, which frequently produce less than 2x phase modulation, and interface circuits, which quantize or incorrectly amiplify signals placed on the spatial light modulator, both can produce systematic phase errors. We examine these effects using a model of correlation-peak amplitude as a function of phase error. The correlation peak is reasonably approximated by the average amplitude across the filter plane. The trends predicted by this new model compare favorably with computer simulations that use gray-scale images.

Horner,J.L., Javidi, B. (1994) Analysis of method to eliminate undesired responses in a binary phase-only filter. *Optical Engineering* 33(6), 1774-6.

Abstract

Several methods have been suggested for eliminating the undesirable convulational and high-order-response terms in a binary phase-only filter (BPOF) (e.g., Zhang, Su, and Guo in 1987, and Davis, Cottrell , Davis, and Lilly in 1989). We show how our previously published (in 1992) analysis of the basic BPOF can be applied to these methods.

Javidi, B., Li, J., Fazlollahi, A., Horner, J. (1993) Improving the illumination of optical pattern recognition systems using nonlinear techniques in the Fourier domain. ***LEOS Conference Proceedings, IEEE Lasers & Electro-Optics Society Annual Meeting*****, San Jose CA. 15-18 November 1993. New York: IEEE, 55-6.**

Abstract

We present an optoelectronic pattern recognition system that can perform image detection in the presence of unknown input scene illumination. The binary joint transform correlator with unknown light illumination is investigated for different thresholding methods.

Javidi, B., Horner, J., Fazlollahi, A., Li, J. (1993) Illumination-invariant pattern recognition with a binary nonlinear joint transform correlator using spatial frequency dependent threshold function. ***Photonics for Processors, Neural Networks & Memories Conference*****, San Diego CA 12-15 July 1993, SPIE Proceedings Vol. 2026, 100-6.**

Abstract

The correlation performance of binary joint transform correlators with unknown input light illumination is investigated for different thresholding methods. It is shown that a binary joint transform correlator that uses a spatial frequency dependent threshold function for binarization of the joint power spectrum is illlumination invariant. The performance of the binary joint transform correlator with unknown input light illumination using a variety of thresholding methods is investigated.

Grycewicz, T.J., Horner,J.L. (1993) Joint transform correlator using a 4-f lens system to achieve virtual displacement along the optical axis. Optical Pattern Recognition IV, Orlando FL 13-14 1993. ***SPIE Proceedings*** **Vol.1959, 372- 80.**

Abstract

The performance of the optical joint transform correlator is severely degraded when multiple targets or multiple identical nontarget images in the input plane produce false peaks in the output plane. One method for overcoming this is to displace the input and or reference plane along the optical axis. This results in the true correlation peaks coming to a focus in an output plane separate from the plane where the false peaks come into focus. These planes are also separated by displacement along the optical axis. The authors show that this separation can achieved by placing a simple lens system along one side of the optical path in the input site of a conventional joint transform correlation. By appropriate lens choice, any virtual displacement can be achieved.

Horner, J.L. (1992) Clarification of the Horner efficiency *Applied Optics*. 31 (23), 4629.

Abstract

Several different definitions of the metric Horner efficiency seem to have come into use. This note is an attempt to clarify and standardize the definition.

Horner, J.L., Giannino. (1992) Effects of quadratic phase distortion on correlator performance. ***Applied Optics*** **31(20), 3876-8.**

Abstract

The deformable mirror spatial light modulator (SLM) has an inherent distortion characteristic that can be approximated as a square-law transfer function. The authors examine the result of this distortion when this SLM is used in an optical correlator.

Fielding, K.H., Horner, J.L. (1992) Clutter effects on the adaptive joint transform correlator. ***Optical Engineering*** **31 (3), 606-13.**

Abstract

The authors consider the effects of clutter in infrared and television imagery on the performance of the joint transform correlator operating in the adaptive mode. Computer simulation results show the energy of the energy object must be greater than the energy of the background to have confidence in the system's tracking capability.

Horner, J.L. (1992) Metrics for assessing pattern-recognition performance. ***Applied Optics*** **31(2), 165-6.**

Abstract

Various metrics used to measure correlation filter performance are discussed. Their similarities and deficiencies are noted, and modifications are suggested. A computer simulation is included to highlight these differences.

Fielding, K.H., Horner, J.L., Makekau, C.K., (1991) An application of optical signal processing: fingerprint identification. Optical Information Processing Systems & Architectures III, San Diego CA 23-26 July 1991. ***SPIE Proceedings*** **Vol.1564.**

Abstract

Describes an optical fingerprint identification system that optically reads a latent fingerprint for correlation using a binary joint transform correlator. The fingerprint is read using the total internal reflection property of a prism. The system was built, tested, and the experimental results are presented.

Flavin, Mary A. & Horner, Joseph L. (1989). Amplitude encoded phase-only filters. ***Applied Optics*** **28 (9), 1692- 1696.**

Abstract

The phase-only filter (POF) and binary phase-only filter (BPOF) have shown to have high optical efficiency, good target discrimination, and virtually no sidelobes. We present a simple method of amplitude encoding the signal phase information. These new

filters have most of the same advantages of a POF or BPOF so that amplitude modulating spatial light modulators or photographic film can be used.

□ **Flavin, Mary A. & Horner, Joseph L. (1989). Correlation experiments with binary phase-only filter implemented on a quartz substrate.** ***Optical Engineering*** **28 (5), 470-473.**

Abstract

We present for the first time results of tests of a binary phase-only filter fabricated by standard VLSI techniques on a fused quartz substrate. We compare computer simulations with direct experimental optical bench tests. In general, the results agree well in terms of narrowness of the correlation peak and its height above the noise floor.

Horner, J.L. (1987) ***Optical signal processing.*** **San Diego, CA: Academic Press.**

Abstract

The book is dvided into seven chapters. Chapter 1 considers white- light processors including colour image processing and white-light Fourier transformations. Pattern recognition is covered by Chapter 2. Topics include optical feature extraction, unconventional correlators and optical implementation of associative memory based on neural network models. Chapter 3 covers temporal signal processing. Nonlinear optical waveguide devices are considered in Chapter 4. Chapter 5 considers transformations including optical transformation and tomographic transformations. Optical numerical processing is the topic of Chapter 6. Chapter 7 considers devices and components.

Horner, Joseph L. & Leger, James R. (1985). Pattern recognition with binary phase-only filters. ***Applied Optics*** **24 (5), 609-611.**

Abstract

The diffraction efficiency of a spatial filter can be an important system constraint. Limited filter illumination or a highly multiplexed impulse response can make detection of the output difficult. A solution to this problem was proposed whereby only the phase of the Fourier transform is recorded on the filter. Correlation experiments with a phase-only filter (POF) have been shown to be highly efffective. A simple model of a phase-only filter is given by a conventional matched filter which is preceded by an amplitude-only filter. The response of the amplitude-only filter is given by the reciprocal of the amplitude of the matched filter. When these two filters are placed in series, the two amplitudes cancel, producing unity amplitude with the appropriate phase.

Gianno, Peter D. & Horner, Joseph L. (1984). Additional properties of the phase-only correlation filter. *Optical Engineering* 23 (6), 695-697.

Abstract

Computer simulations of the scaling and rotation sensitivity of a phase-only filter were performed, showing that it is much more sensitive to such input variations than is classical matched filter. Values of the peak correlation spot power versus both rotation angle and scale factor are presented for both filter types. Several theorems are derived for calculating the optical efficiency of any filter in both input space and frequency space.

AWARDS

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In 1990, Dr. Horner, the inventor, was presented with the Air Force Basic Research Award in recognition of his pioneering work on automatic target recognition using optical filters.

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THE INVENTORS

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BIOGRAPHY OF DR. JOSEPH L. HORNER

Dr. Joseph L. Horner is chief of the Optical Systems Processing Branch of Rome Laboratory's Directorate of Electromagnetics and Reliability, Hanscom Air Force Base, Massachusetts. Rome Laboratory, with headquarters at Griffiss Air Force Base, New York, is the Air Force Materiel Command "super" laboratory for research and development of command, control, communications and intelligence (C4I) technology. A native of Carlisle, Pa., Dr. Horner is a 18-year veteran of the Rome Laboratory staff. He is a 1956 graduate of Haverford College, with a bachelor of science degree in physics. He earned his masters in physics from Bryn Mawr College in 1961 and was awarded his doctorate in 1967 from the University of Michigan. From 1967 to 1969 he worked at Conductron Corporation in Ann Arbor, which was involved in some of the pioneering work on coherent optical signall processing. He received a NRC postdoctoral fellowship to the NASA Electronic Research Laboratory in Cambridge, which later became the DOT Transportation Systems Center. He left there in 1976 to become a consultant to Dr. Edwin Land at the Polaroid Research Laboratory He joined Rome Laboratory in 1978.

Dr. Horner has written more than 80 articles for major research publications and has published two books on optical signal processing. He holds 25 patents and is the inventor of the "Horner Efficiency" metric. He received the 1992 "Inventor of the Year Award " from the Inventors' Association of New England. In 1990, Dr. Horner was presented with the Air Force Basic Research Award in recognition of his pioneering work on automatic target recognition using optical filters. He is the co-inventor, with H. John Caulfield, of the phase-only-filter. His work has made possible a small, light-weight, inexpensive Optical Target Recognition system that can extract a target from a highly cluttered background and then automatically track that target. In addition to signal and image processing, Dr. Horner has also done work in holography, whch culminated in his invention of a series of holographic optical elements as couplers and demultiplexers for fiber optic systems.

Dr Horner is a fellow of the Optical Society of America and SPIE, winner of the AF Basic Research Award, named "Inventor of the Year" by the Inventors Association of New England, and an Aviation Week Laurels Award winner.

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CONTACTING THE TECHNOLOGY TRANSFER OFFICE

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  or just click on this
- **Feedback Form**
  click here

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Appendix H:
Search Engines and Subject Catalogs

Web Matrix: What's the Difference?

Some Answers about Search Engines and Subject Catalogs

This document answers some common questions about Internet services. Although it is organized in question/answer pairs, it's not really a FAQ or terminology reference. However, these are issues that I feel should be addressed for a complete (and honest) discussion. This document will be referenced and linked at appropriate points in the actual Matrix to provide a little more context for the discussion.

Subject Catalogs

What *is* a Subject Catalog?

One way to organize information on the Internet is to create a document or collection that maintains lists of links organized by their content. Such a service, often called a Subject Catalog or Subject Index, is often very easy to navigate and use, since locating desired information is simply a matter of trying the links under an appropriate topic.

Because subject catalogs must be carefully organized, they often require an administrative staff or dedicated contributors and guest editors to locate useful documents and link them under the relevant subject heading. Well-maintained services will often include a brief summary, or Abstract, and other information to help users select the most useful materials.

Subject catalogs are often organized hierarchically to make it much easier to navigate from the general to the specific topic of interest. Well written catalogs also contain cross-references between related topics under different headings such as "Business:Computer Sales" "Computers:Vendors".

A user selects and navigates the links of a subject index by their relation to the desired information, or can simply browse the listed categories for interesting links. Since the documents are grouped by their content, once a suitable file is found, there are often many more links in the same section.

Subject catalogs are useful for people who have a general idea about the information they are seeking, but just don't know where to start.

Is size really important?

The usefulness of a Subject Index is dependent on the value of the of the links it contains. There are 2 approaches that administrators take to maximize the usefulness of their collection.

Services such as YAHOO! and the EINet Galaxy work hard to catalog as many Internet

resources as possible -- typically, hundreds or thousands of document collections a week! Resources are gathered by accepting URL suggestions from users, scanning newsgroups for WWW announcments, and watching other subject catalogs for new links.

By cataloguing as many resources as possible, these servers aim to provide a complete list of relevant documents for each subject area. In this model, the burden of selecting the best resources from this "complete" list is often left to the user.

Other services like the Whole Internet Catalog and IPL follow a different philosophy. Rather than maximizing the number of links on their servers, they keep abreast of efforts and collections in various fields. This does not mean that they don't take suggestions or list new resources, but that linked documents are carefully evaluated before incorporation.

WIC and IPL users will appreciate the extended abstracts and careful maintenance that the administrators provide. The links they recommend are hand-picked as the most valuable or complete within the subject area. Aging and dead links are quickly updated or removed by the staff. A user may not find *all* of the relevant information in a field using such an index, but they will almost certainly find something useful.

How are Subject Catalogs structured?

Most subject catalogs are hierarchically organized into layers from general to specific topics. As the number of links in a catalog increases, it becomes important to effectively organize how the information is organized. Smaller catalogs are often composed of a top-level directory that references secondary pages of links, abstracts, and other information. Smaller catalogs are best suited to novice users, due to the valuable abstracts and carefully moderated links.

Larger catalogs can contain *numerous* levels of abstraction. For example, YAHOO! is organized into 14 general subject headings and 50 sub-headings on the first page. The user must navigate 3 or more index pages to actually find a page of links, but such pages typically contain more than 20 references to documents. In addition, the catalog makes abundant use of cross-references between related headings. The size and complexity of larger catalogs are simplified by careful organization, making them the most useful for general subject browsing.

The Subject Clearinghouse and EINet Galaxy use another technique to index Internet documents. The top-level document describes certain subject headings, which link to fairly comprehensive lists or Internet resources. These lists are generated contributors or "guest editors", who scour the net looking for germane material.

Document lists are suitable for those who need a complete guide to online resources in a particular subject, because they are generally more complete than other services that register URLs from service announcements or user suggestion. However, such collections don't provide value-added services such as document abstracts -- the pages really are organized as simple lists of links.

Who does the work?

Subject catalogs are maintained by a fairly large number of administrator, editors, and contributors. New documents are found by automated search tools, new service

announcements, and user suggestion. For each document, the administrator writes a descriptive abstract and inserts the information into the catalog under the appropriate subject heading or headings. Similarly, outdated documents or dead links must be removed by a human administrator or editor, and is typically handled in response to user feedback.

As the number of indexed documents grows, administrators reorganize subject headings to accomodate and differentiate popular topics into smaller groups. Careful maintenance makes this process of growth and adjustment transparent to the users.

Search Engines

What *is* a Search Engine?

Another way to collect and organize Internet resources uses large databases of information and presents a way to select documents based on certain words, phrases, or patterns within those documents. A Web spider or other software will examine a document and "index", or enter it into the database, based on words extracted from the title or text; in addition, the software also searches the document for pointers or URLs for other documents that haven't been indexed yet.

Once a number of documents have been indexed, the user describes the desired information using selected words or phrases, called "keywords", that are entered into the computer. The search engine then examines the database for documents that match or are related to the user's criteria, and returns to the user a list of the selected documents.

Search engines work on the principle that the information content of a document can be summarized by extracting those words already in the title or text. By ranking the extracted text by its position in title or text, the number of times it appears in the document, and other criteria, the database reduces the number of incidental words or phrases, known as false drops, from those relevant to the topic.

To later retrieve such a document, the user must enter criteria that describe the document as it was extracted and indexed into the database. Often this means a user searching for a particular document must know enough about it to select the best keywords to selectively identify that file.

On the flip side, a user looking for a range of documents in a particular subject area should select representative keywords to select the largest possible set while eliminating incidental matches and false drops. Effective use of keyword controls, such as Boolean and proximity operators, can focus or expand the results of a search as desired.

Search engines with larger databases are typically much more likely to contain relevant and larger result sets for given criteria. For this reason, most search engines strive for and advertise the number of documents they have indexed.

Since document gathering is usually performed by automatic software, the database is rebuilt regularly. This means that new or updated documents are often indexed shortly after coming online, and that dead links are removed in timely fashion. The database

grows because the indexing software saves new links it discovers, as well as user suggested URLs, which can be explored and the indexed in the next cycle.

Is size really important?

Probably the most important, and certainly the popular, comparison of search engines is based on the number of documents indexed in their database. For this reason, most searchable databases advertise their size proudly and often compare themselves to other well-known services. However, there are several measures of number of documents in a database:

1. Documents where the entire fulltext has been indexed.
2. Documents where the URL, name, and headings or excerpts have been indexed.
3. Documents where the URL and name have been indexed (e.g. images or sounds).
4. Documents where some descriptive text have been indexed.

Some services index the complete text of a document, some only selected portions. Other databases count a document as indexed simply because another document contains its URL -- on the assumption that descriptive text accompanies such a hyperlink! Although each method represents a count of "indexed" documents, only the first is the best measure of a service.

To cut through most of the hype and numbers that are tossed around, the Matrix maintains database statistics for each searchable engine (save WWW Worm, which doesn't show that data).

Fulltext documents in searchable databases:

1. Alta Vista - 21 Million
2. Lycos - 5 Million
3. Inktomi - 2.8 Million
4. InfoSeek - 1 Million
5. WebCrawler - 420,000
6. WWW Worm - *<unknown>*

Astute users will notice that these totals are an order of magnitude larger than any subject index; even YAHOO! has less than 500,000 links. Recognize that a searchable database describes every page in a collection to better represent the content of that collection, but a subject catalog only points to the front page or key pages of a collection. Considering that collections of pages can number 5, 10, 50, or more, the actual number of documents indexed by a subject catalog is significantly higher than the total links would indicate.

What are useful searching features?

Among the popular search engines, there are several key features that I feel are useful to most people. This is my chance to describe why you should care about the checkmarks on the overview charts.

Natural Language Queries: For novice Internet users, this is probably the easiest way to search the Web. Users enter questions in natural English, and the server software extracts relevant keywords to create a database query. For example, the phrase "`Find pages`

about AIDS, cancer, or heart disease" would resolve into the individual keywords AIDS, cancer, heart, and disease.

Boolean Linking: One of the most popular ways servers handle multiple keywords is by linking each with a Boolean AND or Boolean OR. For example, the query "food cajun spice" would return only documents that contain all of the keywords food, cajun, *andspicy* if linked with Boolean AND, and would return any documents containing any one of the keywords food, cajun, *orspicy* if linked by Boolean OR. Although certain engines simply perform one kind of linking, others let you select whether to perform a narrow search using AND or a broad search using OR.

Boolean Controls: Similar to Boolean Linking above, this method connects multiple keywords with Boolean operators to improve a search by narrowing or broadening the search criteria. However, this technique provides much more control over the search parameters, because the user specifies how the words are linked using each of the Boolean operators AND, OR, and NOT, as well as the proximity operator NEAR. Using parentheses to group operations, users can create complex Boolean queries such as "((dog OR animal) AND (bite OR bitten)) OR rabies".

Note: The Overview document categorizes both Boolean Linking and Boolean Controls under the same header. Services that only support a single form of linking are typically rated lower than those which let the user specify whether to link with AND or OR. Similarly, servers which support complex Boolean syntax are rated much higher.

Keyword Controls: Rather than requiring some relation between keywords, some search engines allow the each keyword to be qualified individually. Each keyword in the query can be prefixed with special characters like + or - to indicate that they are required (much like Boolean AND) or that they are required to *not* be in the document. Often, unqualified keywords are linked a Boolean OR by default. For example, the Keyword Control query "candy sugar dentist -saccharine +cavity" is equivalent to the Boolean "(candy OR sugar OR dentist) AND (NOT saccharine) AND cavity".

Keyword Truncation: Finally, most systems perform some sort of suffix management on keywords. This helps users to get the most for their queries by generalizing each keyword to its root, and expanding the search to include all forms of that root word. On such a server, a query containing the keyword computers may actually return documents containing compute, computed, computer, computes, computers, and computing. Some servers allow the user to choose which words are truncated, typically by appending a * character to the end of the root word, like comput*; most others, however, perform the truncation automatically according to their own rules.

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Appendix I:
Search Engine Features

Web Matrix: Overview Matrix

Your Internet Service Shopping List

This is the real meat of the Matrix and where it earns its name. For each server described on its own page, the charts below represent a checklist of features and attributes in a unified interface. In addition, various sections of the charts are linked to relevant descriptive or background material located in this document or elsewhere in the collection.

For users with different browsers, there are both graphic and text-only views of this information.

Matrix Keys

In creating these checklists, I wanted to do more than indicate the presence or lack of a feature with a simple check/no-check system. On the other hand, I also wanted to avoid a rating scale from 1-10 or 1-100, simply because I didn't want to judge whether one server's feature was 5% better or worse than another's.

To this end I chose the following 4 element scale, which sorts the evaluations logically (and graphically):

'*' **Bullet or Asterisk**
: An excellent and rather complete implementation of the function. For example, a system with boolean searching that supports complex queries.

'+' **Plus Sign**
: Acceptable functionality, but lacking a robust implementation. Such a system would let you select whether to join multiple keywords with Boolean AND or Boolean OR, but nothing more.

'-' **Minus Sign**
: A poor level of support for the function, typically because it is implemented in terms of other functionality. An example of this would be a system that simply decides whether multiple keywords should be connected by Boolean AND or Boolean OR, regardless of user convenience.

' ' **Blank**
: The function is simply not supported on this server.

Just because one feature is rated with a plus while another is minus, it doesn't represent an absolute judgment of quality; rather, I mean it to indicate a rough comparison of the same feature across servers. If you *still* feel that a mistake or injustice has been made, please feel free to mail me.

Overview Matrix

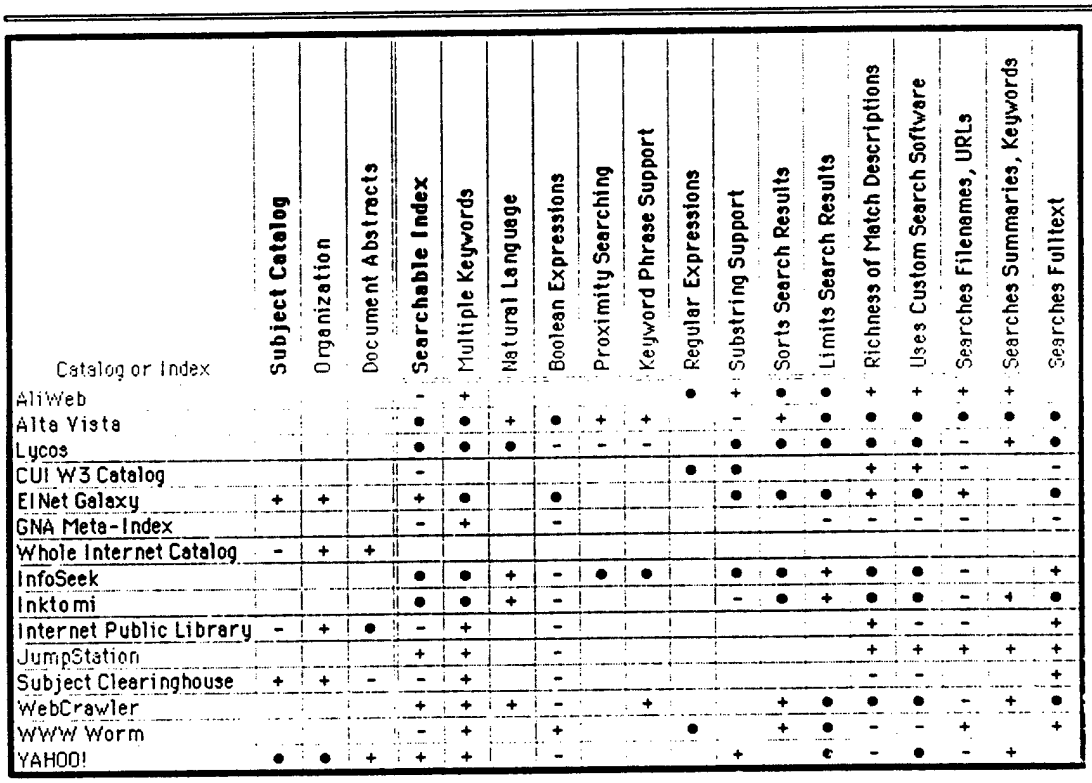
Catalog or Index	Evaluation	Total Documents	Web, Gopher Documents	FTP, ListServ, Usenet, IRC	Other Databases	Clarity of Interface	Speed of Interface	Image Download Time	Text-Only Support	HTML Forms Support	Non-Forms Support	in United States
AliWeb	2	6,000	+	-		-	+	●	●	●		+
Alta Vista	5	21,000,000	●	●		●	●	-	●	●		●
Lycos	5	5,000,000	●	●		●	●	+	●	●	●	●
CUI W3 Catalog	2.5	12,500	-	-		-	+	●	●	●	●	-
ElNet Galaxy	4.5	350,000	●	+		●	●	+	●	●	●	●
GNA Meta-Index	1	3,000	-	+			+	+	●		+	●
Whole Internet Catalog	2	2,000	+			+	+		●			●
InfoSeek	4.5	1,000,000	●	●	●	+	●	-	●	●		●
Inktomi	3	2,800,000	●				●	+	●	●		●
Internet Public Library	3	1,000	+			+	+	●	●	●		●
JumpStation		275,000	●	+		-	+	●	●	+	+	-
Subject Clearinghouse	3	32,000	●	●		+	+	●	●		+	●
WebCrawler	4.5	420,000	+	+		+	+	-	●	●	●	●
WWW Worm	2	<unknown>	-	-		-	+	●	●	●		●
YAHOO!	5	185,000	●	●		●	●	+	●	●		●

Overview Criteria

- **Catalog or Index Name**: The abbreviated name of the Web Index.
- **Evaluation of the Index**: A comprehensive value that reflects the author's evalution of the index for general Internet navigation and locating particular documents or services, on a scale of 1 to 5 Spiders.
- **Number of Documents**: The number of Web, Gopher, FTP, and other documents referenced by this collection. Keep in mind that some subject catalogs keep a short list of hand-picked rich resources, but the effectiveness of a search engine is proportional to the size of its database.
- **Contains Web and Gopher Links**: The index contains resources found on the Web, Gopher, or both.
- **FTP, UseNet, ListServ, IRC**: The index contains pointers to FTP or other well-known types of Internet resources.
- **Other Databases**: The index contains information gathered from sources that are not located on the Internet, such as MedLine, newspaper newswires, or other commercial databases.
- **Clarity of the Interface**: The layout of the search interface and other pages is easy to learn and use. Well-designed services will offer navigation services across the collection, poor services will be disorganized or littered with obscure link icons.
- **Speed of the Interface**: Relative speed of the server's links and download time for the images. Typically reflects how many users connect to the index, the quality of the search software, the speed of the server hardware, and the server's support for load balancing.
- **Image Download Time**: For each service with a logo or imagemap interface, how

much it affect the download time? A small logo is acceptable, but large images, numerous icons, and textured backgrounds cost download speed and bandwidth.

- **Text-only Support**: Support for disabling images and text-only browsers means includes functional navigational aids and alternative to the information in images or icons.
- **HTML Forms Support**: Reflects how well the server make efficient use of HTML Forms in the search interface and in feedback links.
- **Non-Forms Support**: Certain browsers do not support HTML Forms, and must rely on simpler search interfaces. If the server supports non-forms searches, how robust and useful is the search engine?
- **Located in the United States**: The Web server or a mirror site is located in the United States (not even Canada), indicating faster and more reliable network access.



Catalog or Index	Subject Catalog	Organization	Document Abstracts	Searchable Index	Multiple Keywords	Natural Language	Boolean Expressions	Proximity Searching	Keyword Phrase Support	Regular Expressions	Substring Support	Sorts Search Results	Limits Search Results	Richness of Match Descriptions	Uses Custom Search Software	Searches Filenames, URLs	Searches Summaries, Keywords	Searches Fulltext
AliWeb				-	+					●	+	●	●	+	+	+	+	
Alta Vista				●	●	+	●	+	+		-	+	●	●	●	●	●	●
Lycos				●	●	●	-	-	-		●	●	●	●	●	-	+	●
CUI W3 Catalog				-						●	●			+	+	-		-
EINet Galaxy	+	+		+	●		●				●	●	●	+	●	+		●
GNA Meta-Index				-	+		-						-	-	-	-		-
Whole Internet Catalog	-	+	+															
InfoSeek				●	●	+	-	●	●		●	●	+	●	●	-		+
Inktomi				●	●	+	-				-	●	+	●	●	-	+	●
Internet Public Library	-	+	●	-	+		-							+	-	-		+
JumpStation				+	+		-							+	+	+	+	+
Subject Clearinghouse	+	+	-	-	+		-							-	-			+
WebCrawler				+	+	+	-		+			+	●	●	●	-	+	●
WWW Worm				-	+		+			●		+	●	-	-	+		+
YAHOO!	●	●	+	+	+		-				+		●	-	●	-	+	

Features List

- **Catalog or Index Name**: The abbreviated name of the Web Index.
- **Subject Index**: The information in the index is organized by subject area, typically in a hierarchic tree of information.
- **Organization**: The organization of the links, including number and depth of subjects, as well as cross-references and general ease of use.
- **Abstracts**: Amount of descriptive information that accompanies links.

- **Searchable Index**: The information in the index is stored in a database, which is accessed by entering relevant search criteria, called keywords, and then displayed

in a list of links to the desired documents.

- **Multiple Keywords**: Users can expand or restrict databases searches by entering more than one keyword. Additional controls are often necessary for flexible control over the query.
- **Natural Language**: The ability to accept a query in natural language (as if asking a simple question), ignoring common or incidental words (`the`, `is`, `and`) and extracting relevant keywords for the search.
- **Boolean Searching**: For servers that allows Boolean Searching, this field reflects the sophistication of the feature. Many servers automatically join keywords with Boolean AND or Boolean OR, but only Alta Vista and EINet Galaxy supports complex criteria.
- **Proximity Searching**: The ability to select a document based on the proximity of the keywords in the text. As a rule of thumb, this means that documents with incidental keyword matches will be rated lower than others with highly relevant content.
- **Keyword Phrase Searching**: In selecting highly related keywords, it may be desirable to treat them as a single word phrase to encourage the search engine to find them together. For example, using `"Bill Gates"` as a query will generate better matches than the Boolean `"Bill AND Gates"`. Phrase searching provides much more specific functionality than either Boolean searching or Proximity Searching.
- **Regular Expressions**: A sophisticated method for specifying keyword patterns, using wildcard characters and other matching functions; its generally available on search engines that are based on Perl or `grep` software.

  Substring Searches: This feature represents the ability to enter a complete or partial word and generate matches containing it. Exceptional servers will examine the keywords a user has entered, and identify the appropriate root word to use as a substring search; I commonly refer to this functionality as Root or Suffix Management.
- **Sorts Search Results**: Many search engines will list the result sets in order of calculated relevance, typically listing the best matches toword the top of the results document and degenerating into poorer matches toward the bottom. This feature makes its easy for users to identify and print only the best 10 or 50 matches in a set.
- **Limits Search Results**: Some servers allow the user to specify a maximum number of documents to return, thus providing better response time and a focused result set. Certain servers enforce a maximum number of search results, to lessen the server load or to encourage user subscription.

  Richness of Match Descriptions: This value reflects relevant background information for the documents in the result set, such as match quality, file location. file size, file timestamp, or extracted passages. The more information that a service provides, the easier it is to identify *useful* documents in the match set.
- **Custom Search Software**: The software that performs a search is critical to the speed and functionality of the service. Servers written using Perl, awk, or other simple scripting tools are much slower than custom software solutions written in C or using special database software.
- **Searches Filenames and URLs**: Servers that can search the filenames and locations are useful for locating documents in a particular location or by a particular author. Unfortunately, such searches often interfere with keyword searches because machine or user names may incidentally match search criteria (such as `www-genome.wi.mit.edu` or `forestry.umn.edu`).
- **Searches Summaries and Keywords**: This is perhaps the most reliable type of

search, because the the search engine examines very specific words or phrases, rather than the incidental text and file locations. Summaries are a good way to assist search software in finding relevant documents, but require administrative work and the establishment of consistent descriptors and vocabulary control standards.

- **Searches Document Fulltext**: The most flexible type of search, this method applies a brute force search the complete content of the documents for possible matches. Although time-consuming and prone to error, fulltext searches can be simplified or focused with tools such as root management or proximity searching.

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Appendix J:
Search Engine Review

Matrix, Search Engines Sample Index

Full Name of the Index

Simple descriptive text for the indicated Web Index.

Key Links

URL for Front Page:
URL for Top-level Page:
URL for Forms Search Page:
URL for Non-Forms Search Page:
URL for Copyright/Legal Page:
URL for FAQ Page:
URL for Help Page:
URL for Subscription Page:
URL for Creator's Page:
URL for Author's or Staff Page:
URL for Sponsors or Partners Page:
Home Organization:

Organization

- ☐ Is it a Subject Index?
  - ☐ Cross References?
  - ☐ Breadth and Depth
- ☐ Is it Searchable?
  - ☐ Underlying Search Engine
  - ☐ Features and Limitations
    - ■ Multiple Keywords
    - ■ Boolean Expressions
    - ■ Regular Expressions
    - ■ Proximity Searching
    - ■ Controlled Vocab
    - ■ Root/Suffix Mgmt
  - ☐ Quality of Hits (min-score), Max Hits
  - ☐ What does it search? (filenames, titles, subject, summaries, fulltext)
- ☐ Forms/non-forms support?
- ☐ General or Specialized Content?

Administration

- ☐ Gathering - Human, Automatic, User Registered
- ☐ Speed of Engine or Interface
  - ☐ Number of servers (automatic balancing?)
  - ☐ Average Load (Morn, Aft, Eve)

- ☐ Average Processing Time
- ☐ Quality of Index
  - ☐ Number of New Links
  - ☐ Number of Dead Links
  - ☐ Size of the Collection
  - ☐ Clarity of search page or index
- ☐ Additional Services?
  - ☐ Online Help?
  - ☐ Navigation Aids
  - ☐ Search Tutorials
  - ☐ Server Load Indicators
  - ☐ What's New page
  - ☐ What's Good page
  - ☐ What's Popular page
  - ☐ User Registration page
  - ☐ Document Rating, Summary, Extract, Timestamp, etc

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Matrix, Search Engines: Alta Vista

Probably the most powerful Web search engine available, Alta Vista is a great demonstration of what great hardware and software Digital makes. However, more than an advertisement, Alta Vista is a very complete and robust tool which boasts one of the largest indexed databases available.

Casual users can slap down a few words to generate a simple query, but power users will appreciate the flexibility of the advanced search interface. In fact, considering the number of users and the size of the database, it's a wonder that this service is free and (almost) advertisement free!

Key Links

URL for Front Page: `http://www.altavista.digital.com/`
URLs for Search Pages:

- Simple Search `http://www.altavista.digital.com/`
- Advanced Search:
  `http://www.altavista.digital.com/cgi-bin/query?pg=aq&what=web`

URL for Legal Page:
`http://www.altavista.digital.com/cgi-bin/query?pg=legal`
URLs for Help Pages:

- Simple Search:
  `http://www.altavista.digital.com/cgi-bin/query?pg=h&what=web&stq=0&`
- Advanced Search:
  `http://www.altavista.digital.com/cgi-bin/query?pg=ah&what=web&what=`
- Other Search Tips:
  `http://www.altavista.digital.com/cgi-bin/query?pg=tips`

URL for Staff Page:
`http://www.altavista.digital.com/cgi-bin/query?pg=about&text=yes#wet`
Home Organization: Digital Equipment Corporation (DEC).

Organization

- Alta Vista provides 2 complete search interfaces, each of which can search across indexed Web pages or recent Usenet news articles.
- The simple interface accepts a straight list of keywords or quoted phrases, with optional modifiers + and - to require or prohibit a word.
- The advanced interface supports full Boolean and Proximity searching, using paretheses to control nesting of arbitrarily complex criteria. is well as search constraints and suffix wildcards. Users can also specify a the earliest or latest modification date for matching documents.
- Both interfaces can contrain searches for keywords to the fulltext, title, URL, or

host of a Web page, as well as perform suffix expansion up to 5 characters using the * wildcard. Keywords are treated as case-insensitive if all lowercase, otherwise they are fully case-sensitive.
- Neither search page will automatically truncate a keyword, nor do they accept Regular Expressions.
- There are no controls to specify the number of matches displayed on the output page, but each page contains a link to the next set of 10 matches. Query results can be displayed with in standard form (title, extracted text, URL, hotlink, size, timestamp), compact form (shortened title, timestamp, and short extract), or as simply a count of matching documents.
- Documents are sorted on the input keywords, but the advanced form let's the user enter *additional* words on which the documents will be sorted.

- Using the search engine requires an HTML-forms capable browser.
- Indexed documents are not restricted by content or focus.

Administration

- Document discovery and indexing is carried out automatically by dedicated workstations.
- The service runs across 4 separate Digital Alpha workstations, each dedicated to a different administrative task and packed with processors, memory, and disk space.
- The software was developed at Digital to utilize the hardware efficiently. The search engine and indexing software are multi-threaded custom software packages. Even the most complex searches I used returned in about 5-15 seconds.
  The service database indexes the full text of over 21 Million Web pages (updated daily) and 13,000 Usenet newsgroups (updated in real time). The search engine traverses about 2.5 million documents a day!
- Each page is well-organized and clean. The only graphics are the title bar images, and the server is text-browser friendly.
- Additional Services
  - Each search interface provides an extensive help page, which details how to construct a query, how to improve a query, and how the server interprets and uses a query. In addition, there are answers to frequently asked questions regarding search results, such as why they may include unwanted data or not include pages the user expected.
  - The Tips page demonstrate some simple or interesting search options that you may not have considered.
  - The title bar is a simple, if not a bit large, navigation tool that is present across all pages. Results pages start with the selected search engine form, filled with the parameters for the displayed query.
  - Users are encouraged to suggest URLs or new documents to search.
  - The service also provides a Surprise page, from which the user can select a category and be whisked off to a random page related to that subject.

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Matrix, Search Engines: InfoSeek

InfoSeek is a commercial fulltext search service that for finding online information. Searches examine WWW pages, Usenet newsgroups, over 80 computer magazines, newspaper newswires and press releases, company profiles, medical information, movie reviews, technical support databases, and much more.

The service is divided into 2 portions, InfoSeek Guide and InfoSeek Professional. The Guide provides limited free access to certain portions of the InfoSeek database. The Professional portion offers data from each of the services listed above, but is provided at a charge to registered users.

Key Links

URL for Front Page: `http://www.infoseek.com/`
URL for Forms Search Pages:

- **Free Search**: `http://guide.infoseek.com/`
- **Registered Users**: `http://professional.infoseek.com/`

URL for Copyright Page: `http://guide.infoseek.com/IS/Home?disclaimer.html`
URL for Legal Page: `http://www.infoseek.com/doc/stddoc/HowItWorks.html`
URL for FAQ Page: `http://professional.infoseek.com/doc/FAQ/FAQ.html`
URL for Help Page: `http://guide.infoseek.com/IS/Help?DChelp.html`
URL for Subscription Page:
`http://professional.infoseek.com/doc/help/InfoSeekIntro.html`
URL for Sponsors Page: `http://www.infoseek.com/doc/Sponsors.html`
Home Organization: InfoSeek Corporation

Organization

- InfoSeek is a strictly searchable Internet index.
  - The InfoSeek search engine is based on a custom software and database engine, written in Python (similar to Perl). To see a comparsion of search engine features, check out their Search Technology page.
  - Features and Limitations
    - The server supports Multiple Keywords, and can successfully resolve even free text query strings.
    - True Boolean searches are not supported, however keywords can be required or filtered by prefixing them with '+' or '-' character.
    - The server does not perform wildcard or pattern-matching searches.
    - By quoting or hyphenating words, the engine will treat them as a phrase. It will then search for documents where these words occur together and in that order.
    - Enclosing keywords in square brackets `[<text>]` will perform a Proximity Search, so that the words must occur together or just near each other in the full text.

        - Keywords are automatically stemmed to the relevant root word before performing the query.
    - Search results are sorted by match quality, but are limited to the top 100 hits (for demo searches) or the top 200 hits (for registered users).
    - Searches are performed on the filenames and fulltext of Web pages, Usenet articles, and so much more.
- Searching and registration require HTML Forms.
- The server contains documents from numerous sources, but does not focus or restrict its content to any particular subject area.

Administration

- Documents are located and indexed by automatic searching software, a custom Worm program, and by user registration of online documents.
- The server and search engine run on an 8 CPU SparcCenter, and additional support pages (help, etc) are located on a secondary server. My test searches over the Web database completed in less than 10 seconds (for both demo and registered interfaces), but the FAQ warns that UseNet searches may take up to 60 seconds.
- For registered users, the server collection boasts over 400,000 Web pages, recent Usenet posts, 80 computer periodicals, newswire services, Medline, movie reviews, and *many* more. The free guide interface only searches certain databases.
- Additional Services
    - Documents and services are explained in detail across abundant and well-written help pages and FAQ documents.
      Important links are located at the top and bottom of each page, as quick navigational aids.
    - The server provides concise explanations for various search parameters and sample queries to try out.
    - Server Load Indicators
    - Users are encouraged to register Web pages with the search engine.
    - Search results include document title, sample text, match quality, document link *and* printed URL, and the file size of the returned document.

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Matrix, Search Engines: Lycos

Lycos Inc.: The Catalog of the Internet

The name Lycos is derived from the abbreviation of *Lycosidae*, the latin name for Wolf Spider. The nickname reflects the automated tool used to find and catalog URL's, commonly called a *Web Spider*.

Currently, Lycos boasts an index for over 19 Million unique URLs -- reportedly 91% of the Internet! However, as the Inktomi count page mentions, this really represents the fulltext of only 4.8 Million Web pages, and the "abstracts" (the descriptions in the first 4.8M) for another 6.7 Million Web documents and 7.4 Million binary files.

Key Links

URL for Front Page: `http://www.lycos.com/`
URL for Forms Search Pages:
`http://www.lycos.com/cgi-bin/nph-randurl/cgi-bin/largehostform1.html`
URL for Non-Forms Search Pages:
`http://www.lycos.com/cgi-bin/nph-randurl/cgi-bin/largehostformless1.html`
URL for Copyright/Legal Page: `http://www.lycos.com/reference/legal.html`
URL for FAQ Page: `http://www.lycos.com/info/faq.html`
URL for Help Page: `http://www.lycos.com/info/index.html`
URL for Creator's Page: `http://fuzine.mt.cs.cmu.edu/mlm/home.html`
URL for Staff Page: `http://www.lycos.com/lycosinc/bios.html`
URLs for Sponsors Pages:

- Business Partners:
  `http://www.lycos.com/lycosinc/business-partners.html`
- Advertisers: `http://www.lycos.com/lycosinc/advertising.html`

Home Organization: Originally created at Carnegie-Mellon University, Lycos is now its own corporation.

Organization

- Exclusively Searchable Database:
  - Underlying Search Engine: A custom software solution, which has been designed to handle large amounts of data. Recent optimizations have improved performance of this system from 4 to 6 times faster.
  - Features:
    - Multiple Keywords, with control over how many terms are required.
    - Control how tolerant you are regarding suffix and prefix matching: loose, fair, good, close, strong.
    - Specify Maximum Hits and Minimum Score for Search
    - Control the display of query results, such as number of items per page and the level of descriptive detail.

- Limitations:
  - No true Boolean support
  - No specifiable Proximity Searching
- Lycos scores words by how far into the document they appear; thus hits in the title or first paragraph are scored higher.
- Search results include match score, document timestamp, length, number of links, document title, headings, and sample extract.

- Forms and non-forms interfaces available, but only the forms interface lets you control many of the parameters.
- The content is not restricted in any way, except to eliminate overwhelmingly common terms such as HTML, GIF, and Web.

Administration

- Lycos uses automated gathering software (a Web Spider) to find and catalog new documents. Users are also able to suggest new URLs for inclusion in the Lycos database.
- Search Engine Specifics
  - Lycos provides *many* machines for performing searches, and performs load balancing to lessen the processing load on these computers. (You may be pointed to another machine with a lighter load.)
  - Due to the overwhelming size of the Lycos database, and the large number of people who used it, Lycos used to be very slow and unresponsive. That is no longer the case! With new funding, the hardware and software configuration is more than adequate to suffer the load, and can perform most simple queries within a few seconds.
  - For more information, you can examine tables and charts depicting:
    - Number of URLs in the catalog
    - A comparison to other catalog and search tools
- Quality of Index
  - As of Jan. 15th, the index catalogued over 11 million Web documents.
  - An average of 300,000 documents are being added each week.
  - Since the database is rebuilt weekly, the number of dead links is negligible.
  - Both the basic search page and the forms interface are very straightforward. The latter also provide pointers to a help page describing how to construct a query.
- Additional Services and Features
  - The server provides Help, FAQ, and Search language help.
  - The server permits both URL registration and deletion by users.
  - Lycos maintains a list of the most useful or interesting pages, calculated by the number of links which point to those pages.

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Matrix, Search Engines Open Text

Open Text Index

Open Text is a very nice system which provides 3 search interfaces with increasingly powerful features. Simple Search accepts multiple keywords as a phrase or Boolean Linked, Power Search is based on complex Boolean queries and can specify which portions of a document to search, and the Weighted Search interface searches for multiple keywords but allows the user to assign a relative weight each term when displaying the result set.

Key Links

URL for Front Page: `http://www.opentext.com/omw/f-omw.html`
URLs for Forms Search Pages:

- **Simple Search**: `http://www.opentext.com/omw/f-omw.html`
- **Power Search**: `http://www.opentext.com/omw/f-omw-comp.html`
- **Weighted Search**: `http://www.opentext.com/omw/f-omw-rank.html`

URL for Copyright Page: `http://www.opentext.com/omw/f-copyright.html`
URL for FAQ Page: `http://www.opentext.com/omw/f-faq.html`
URL for Help Page: `http://www.opentext.com/omw/f-hlp-simple.html`
Home Organization: Open Text Corporation

Organization

- The Open Text Index is strictly a searchable database of Web documents.
- The Web crawler and search engine are based on custom software products sold by the Open Text corporation.
- Among the 3 engines. users can perform: multiple keywords or phrases, complex Boolean queries, proximity searching, and weighted searches.
- The query software does not perform any sort of suffix management (you must enter in all variations of a keyword, such as plurals or alternate spellings), nor does it support wildcards or regular expressions.
- Both the Power Search and Weighted Search interfaces allow the user to specify what portions of a file to search for each keyword: fulltext, summary,
- There are no limits placed on the number of query terms or number of results returned for any given query.
- The data indexed in the database are Web pages, gopher links, and FTP files, but are not restricted by content.

Administration

- The database is maintained by automated search software which adds, removes, and updates links periodically.

- Queries tend to return within about 5-10 seconds.
- The database contains the fulltext of 5 Million Web documents, and indexes new links at the rate of 10s of thousands.
- Each of the search pages is very simple and easy to use, although it is rather difficult to navigate to the Weighted Search page or other pages not included in the navigation graphic.
- Additional Services
  - The service provides help for each kind of search interface: Simple Search, Power Search, and Weighted Search help pages.
  - Amoung the search pages, there is a search tutorial, to help new users get started with some of the simple features, and learn some of the more powerful toos.
  - The navigation graphic, although a bit large, is very modest and easy to use. However, there are many useful services that are not represented within the graphic.
  - Users are encouraged to submit pages for indexing in the database.
  - Search results include a URL, hyperlink, document title, extract, and a "search score". Each result includes a link for generating related queries, as well as a summary document which describes the keyword matches and how that document fell into the result set.

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Matrix, Search Engines: WebCrawler

The WebCrawler is a tool for searching for Web documents. It constructs a database by traversing the Internet using a *Web Robot* and then indexing the full text with a simple filtering mechanism. The search engine processes each user request by evaluating each document against the keywords to compute a weighted sum, then returns a sorted list of matching documents.

Key Links

URL for Front Page: `http://webcrawler.com/WebCrawler/Home.html`
URL for Forms Search Page: `http://webcrawler.com/`
URL for Non-Forms Search Page: `http://webcrawler.com/cgi-bin/WebQuery`
URL for FAQ Page: `http://webcrawler.com/WebCrawler/Help/FAQ.html`
URL for Help Page: `http://webcrawler.com/WebCrawler/Help/Help.html`
URL for Creator's Page: `http://info.webcrawler.com/bp/bio.html`
URL for Staff Page: `http://webcrawler.com/WebCrawler/Facts/Team.html`
Home Organization: Originally created at University of Washington in Seattle, WebCrawler is now owned and operated by America Online, Inc.

Organization

- WebCrawler is an exclusively searchable database of Web documents, built on a custom software engine written by the author using C.
- Features and Limitations:
  - Supports simple Boolean OR (by default) or Boolean AND (by clicking the Forms checkbox) across multiple keywords, but doesn't handle Boolean Not, complex Boolean combinations, or Proximity Searching.
  - The databases creates its indexes by identifying words on space and punctation boundaries, converts them to lowercase, and strips off common suffixes such as `-s`, `-er`, and `-ment`. It also filters out common words such as `web`, `Internet`, `be`, `and`, and `or`.
  - The server weights the hits on the quality the match between keywords and documents, then returns the highest ranking documents in sorted order. The user specifies the number of hits as discrete amounts (10, 25, 100, or 500).
  - The engine indexes and searches across filenames, document titles, as well as full textual content.
- WebCrawler provides both Forms and Non-forms interfaces to the search engine, however Forms support is required for most of the search features.
- The information catalogued by WebCrawler has no specific focus or content restrictions.

Administration

- Document information is gathered automatically by a custom Web searcher and from user-suggested URL's.

- Average response time for basic access is about 5 seconds, and searches return within 30 seconds.
- The server runs on a Pentium computer under *NextStep*, and the dcoument gathering engine operates from a similar second machine. The WebCrawler index currently contains information on over 420,000 documents.
- The layout and organization of the server are very simple and the information provided is quite helpful. The flexibility of the search engine (smart truncation, etc), the simplicity of the search page, and the formatting of the search results make the server ideal for new and experienced users.
- Additional Services
  - The help page demonstrates sample queries, with suggestions for improving search quality, and a description of the indexing process.
  - The server maintains a list of the Top 25 URLs linked from other documents. This is not a reflection of the actual traffic on a particular document, but the number of hotlists and index pages that include a pointer to it.
  - The server allows users to suggest documents for inclusion into the search.

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MISSION OF ROME LABORATORY

Mission. The mission of Rome Laboratory is to advance the science and technologies of command, control, communications and intelligence and to transition them into systems to meet customer needs. To achieve this, Rome Lab:

a. Conducts vigorous research, development and test programs in all applicable technologies;

b. Transitions technology to current and future systems to improve operational capability, readiness, and supportability;

c. Provides a full range of technical support to Air Force Material Command product centers and other Air Force organizations;

d. Promotes transfer of technology to the private sector;

e. Maintains leading edge technological expertise in the areas of surveillance, communications, command and control, intelligence, reliability science, electro-magnetic technology, photonics, signal processing, and computational science.

The thrust areas of technical competence include: Surveillance, Communications, Command and Control, Intelligence, Signal Processing, Computer Science and Technology, Electromagnetic Technology, Photonics and Reliability Sciences.